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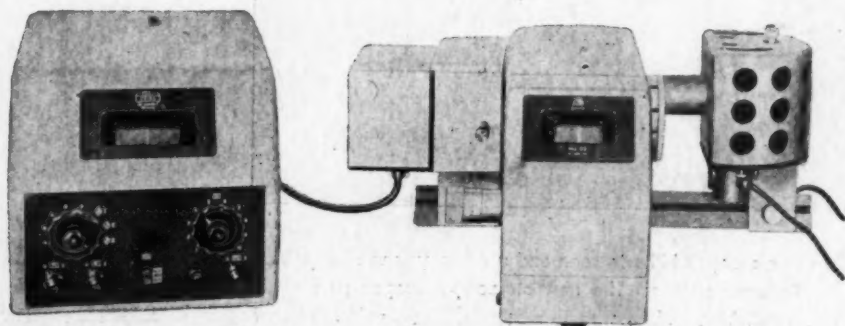
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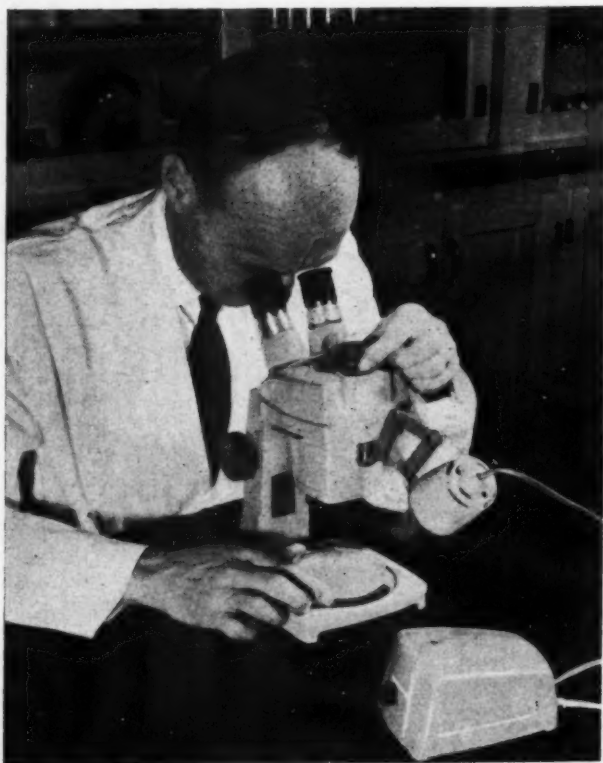
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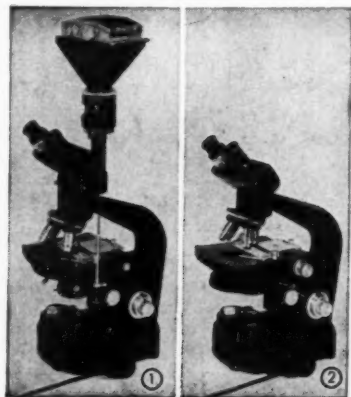
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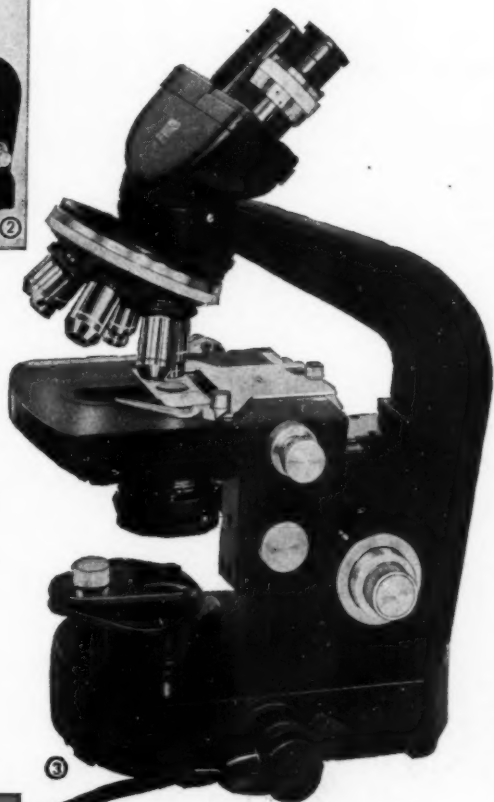
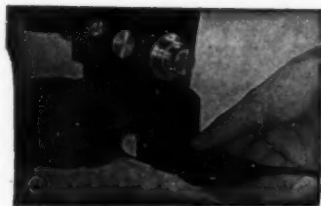


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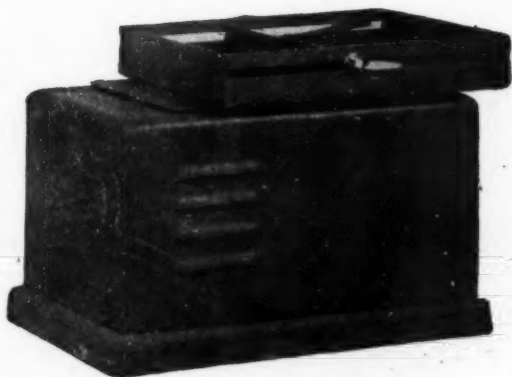


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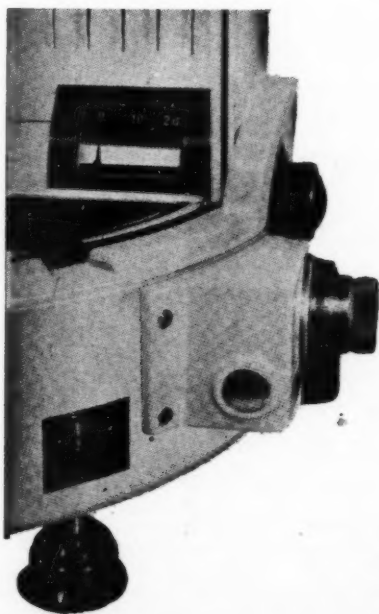
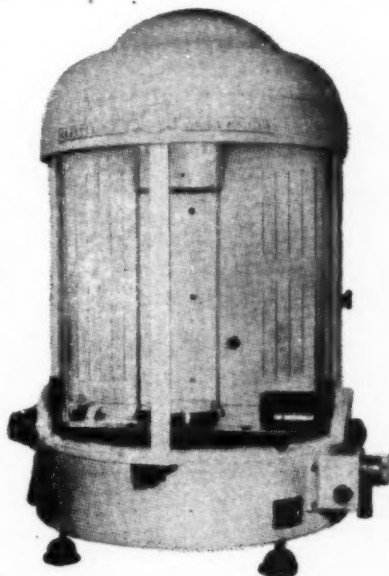
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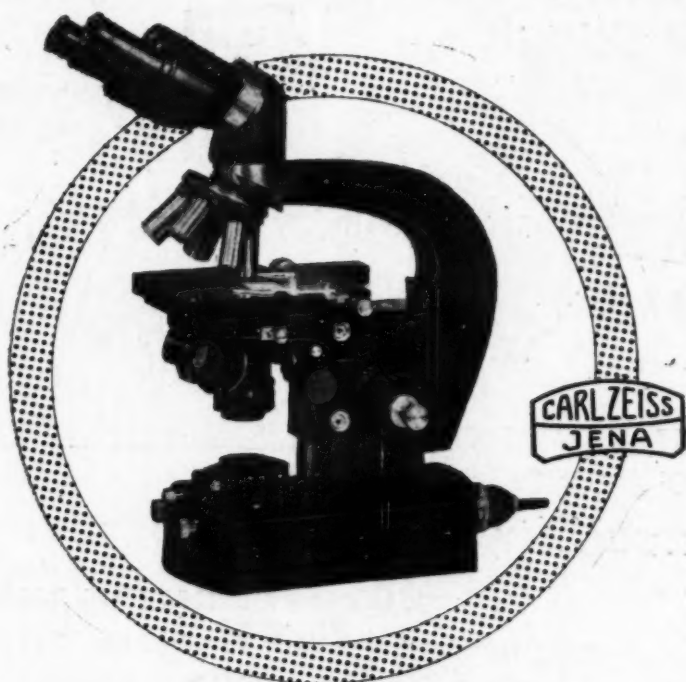
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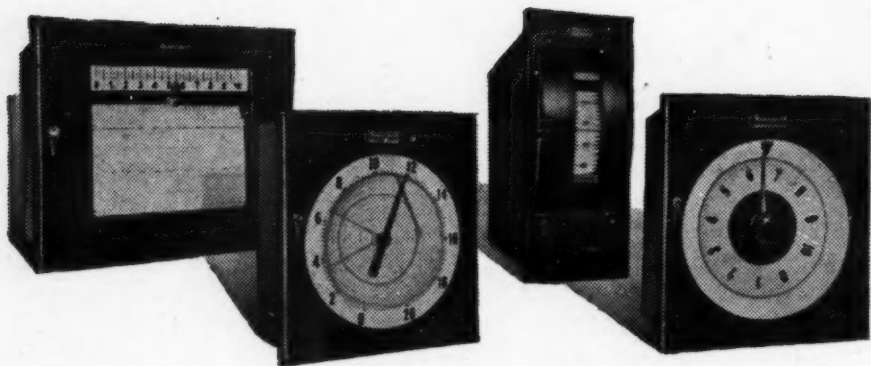
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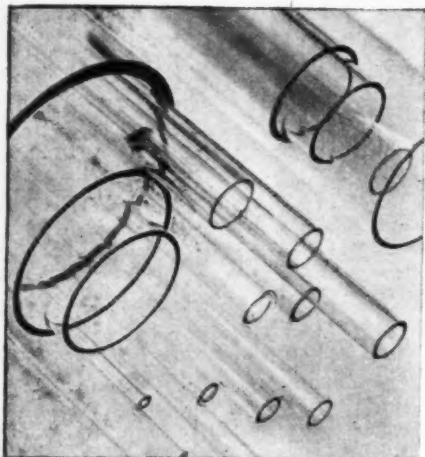
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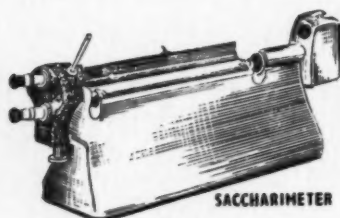
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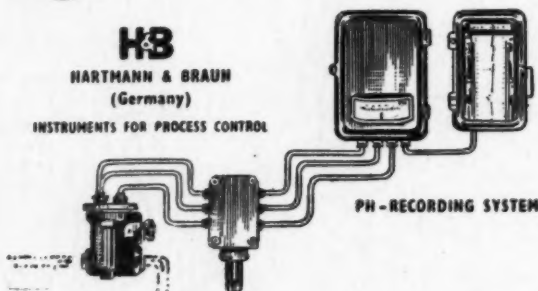
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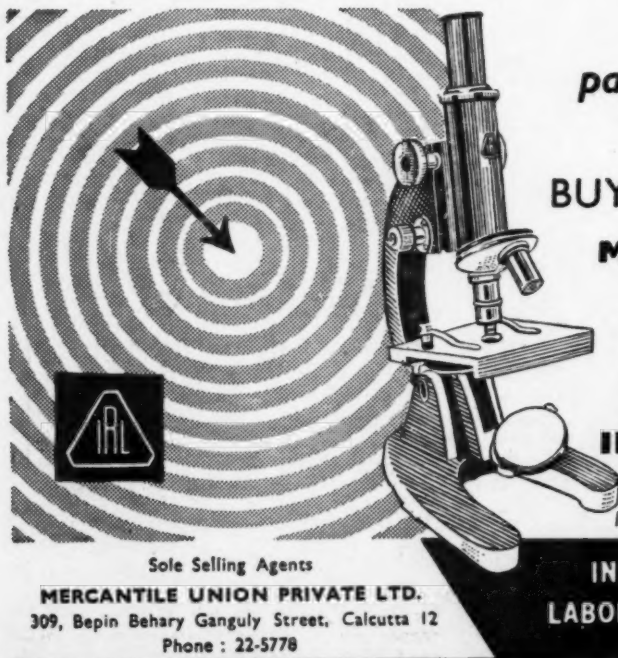
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## THE SEARCH FOR FOSSIL METEORITE CRATERS—II

C. S. BEALS, M. J. S. INNES AND J. A. ROTTENBERG

*Dominion Observatory, Ottawa, Canada*

### THE HOLLEFORD CRATER

THE Holleford Crater, longitude  $76^{\circ} 30' W$ , latitude  $44^{\circ} 47' N$ , was discovered by G. M. Ferguson and A. Landau (Beals, Ferguson and Landau, 1956) as a result of a search of aerial photographs in Southern Ontario. A study of the aerial photographs with the stereoscope indicated a relatively shallow circular depression with some indication of raised edges approximating 1.46 miles in diameter. The village of Holleford lies partly within the crater circumference and several roads cross the rim while one descends close to the floor of the crater. Geological studies on the site indicated that almost the entire crater area was covered by Paleozoic sediments of Ordovician age which dip gently inward toward the centre (Frarey, M. J., 1955). The area has been subject to heavy erosion and the circular form of the feature is more clearly defined in some areas than others but there appears to be no exception to the rule that all strata dip radially inward toward the centre. The crater thus appears to correspond to Type 3 but it also has resemblances to Type 4 and Type 5. The general area in which the crater is located is rather thinly covered with sediments and there are numerous outcrops of Precambrian rock in its immediate vicinity. There appears to be only a single Precambrian outcrop within the circumference and it occurs as a low hillock of crystalline limestone on the north-eastern sector of the crater rim. This outcrop is approximately 38 ft. above the surrounding plain, suggesting that the rim of the crater had not been entirely eroded away before the deposition of sediments. The depth of the visible crater is approximately 100 ft. and the surrounding hills, particularly on the south, east and west form a moderately impressive cirque when viewed from a point near the centre. The adopted centre is at 492 ft. above sea-level, about 12 ft. above the surrounding plain, while the visible rim rises, at its highest point in the south-west, to an elevation of 600 ft. above sea-level. The fact that the true crater rim is covered with sediments renders its exact location difficult, but it is considered that on the average its position can be fixed within 100 ft. On the west the estimated position of the rim is on the edge of a cliff dropping steeply about 150 ft. to Knowlton Lake.

A consideration of the overall geology of the area suggested the existence of a circular basin in the Precambrian basement filled with Palaeozoic sediments. This hypothesis was tested by geophysical observations with the following results.

**Geophysical Results.**—Analyses of the results of geophysical surveys indicate that the physical properties of the crustal rocks underlying the Holleford crater have undergone changes similar to those observed at the Brent crater. As found for Brent the gravity contours at Holleford (Fig. 7) are roughly circular and in a general way follow the outline of the depression. Correcting for regional effects it is found that the crater produces a negative anomaly of about 2.2 milligals. It is impossible accurately to assess the portion of the anomaly that is due to the Palaeozoic sediments now filling the crater and draped over the rim, and that portion that would result from low density fragmental material believed to underlie the sedimentary strata. However, the surface exposures of the latter consists of dense lithographic limestones with densities somewhat larger than those of the surrounding Precambrian rocks. As a considerable thickness of these limestones within the crater would tend to compensate for any sedimentary material of lower density at depth, overlying the crater floor, it is concluded that the total observed anomaly may be taken as a reasonable estimate of the gravitational effect of the brecciated and fractured zone. On this basis and assuming 0.16 gm. per c.c. (as observed at Brent) for the mean density contrast between the fragmental material and normal country rock, the gravity minimum indicates that the breccia zone under the Holleford crater is at least 1,000 ft. thick.

The gravity results, therefore, point to a considerably smaller amount of fragmental material underlying the Holleford crater than was found at Brent, as might be expected considering the relative sizes of the two craters. Because of this and because the characteristically high propagation velocity of the hard lithographic limestone lying within and forming a mantle some 50 ft. thick on the rim and on three sides of the crater prevented penetration of the seismic waves to lower levels, the results of the seismic investigation at Holleford are less



definitive than those obtained at Brent. However, analysis of the travel time curves obtained by firing a number of shots near the centre of the crater and recording them outside at distances of 3,000 to 12,000 ft. from the rim showed definite evidence of an underlying low velocity layer. No such layer was indicated in the records obtained at the same stations for shots fired outside and well removed from the crater

Although no ground magnetic surveys have been carried out over the Holleford crater, an aeromagnetic map of the area was made available for study by the Geological Survey of Canada. The map gives anomalies of total field intensity, contoured at intervals of 10 gammas, and is based upon measurements recorded at a flight altitude of 500 ft. above terrain. The anomaly contours trend in a

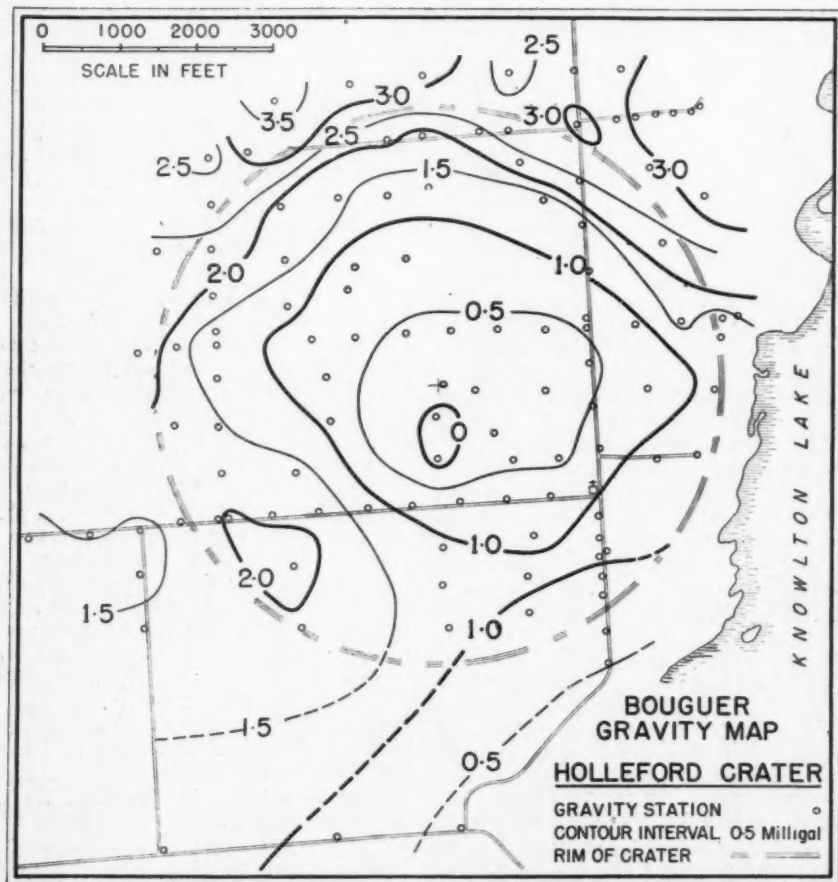


FIG. 7. Gravity contour map, Holleford Crater.

to ensure that the seismic paths traversed undisturbed basement rocks. While no quantitative results as to its thickness were possible, the low velocity material underlying the crater might well be identified with the zone of broken and shattered rock characteristic of craters formed by meteoric impact and explosion.

general north-east direction, consistent with the general strike of the Precambrian rocks, and although there are marked local disturbances as much as 300 gammas in the magnetic field within one-half a mile from the rim, the variation over the crater is quite uniform. There is however a slight widening of the contours,

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indicating a decrease in the magnetic intensity in the vicinity of the crater, which may very well be a reflection of the disturbed bed-rock condition under the crater. Although consistent with the magnetic findings at Brent, the widening of the contours is extremely small and the slight decrease in intensity could very well be the result of other phenomena. Several ground magnetic traverses across the crater might be revealing and provide more significant results. While the aeromagnetic data does not provide definitive evidence in favour of an impact origin, the remarkably uniform gradient, and the absence of magnetic disturbances strongly negates the possibility of a structural or geological origin.

**Diamond Drilling Program.**—Since the geophysical results gave some confirmation to the idea of a crater in the Precambrian basement filled with sedimentary rock it was decided to undertake a diamond drilling program partly

to ascertain the depth and shape of the crater and partly to see whether the material under the sediments would turn out to be the broken and fragmented material expected for an explosion crater. Holes were drilled at distances of (1) 1400 ft., (2) 2500 ft., and (3) 3750 ft. from the centre of the crater. The location of Hole No. 3 was chosen so as to be close to the top of the rim while the other two holes were located on the sloping sides at distances favourable for determining a profile. Limitation of funds prevented the drilling of a third hole at the centre.

The first hole drilled penetrated 755 ft. of sediments and at this level rock fragments of a variety of sizes were encountered embedded in a matrix of finely divided materials which upon microscopic examination turned out to be fragments of the Precambrian basement rock. This fragmented material or breccia was drilled to a depth of 1,128 ft., where the drill struck fast



FIG. 8. Drill cores showing sediments and breccia, Holleford Crater.

and had to be abandoned. While it was a disappointment not to be able to penetrate to the undisturbed basement, the 1,128 ft. of drill cores recovered supplied very valuable information and this was supplemented by additional material from Holes No. 2 and 3. In Hole No. 2 rock breccia was encountered after 440 ft. of drilling through sediments. The breccia continued to a depth of 600 ft. where substantially undisturbed rock was encountered. The hole was pushed to a depth of 1,486 ft. in order to secure massive samples of the basement rock. Hole No. 3, bored on the estimated location of the crater rim, encountered a thin layer of breccia after only 65 ft. of sediments had been penetrated. Undisturbed basement rock was reached at 66 ft. and the hole was continued to a total depth of 443 ft. The contrast between the sediments and breccia is illustrated in Fig. 8 showing a selection of cores from Hole No. 1.

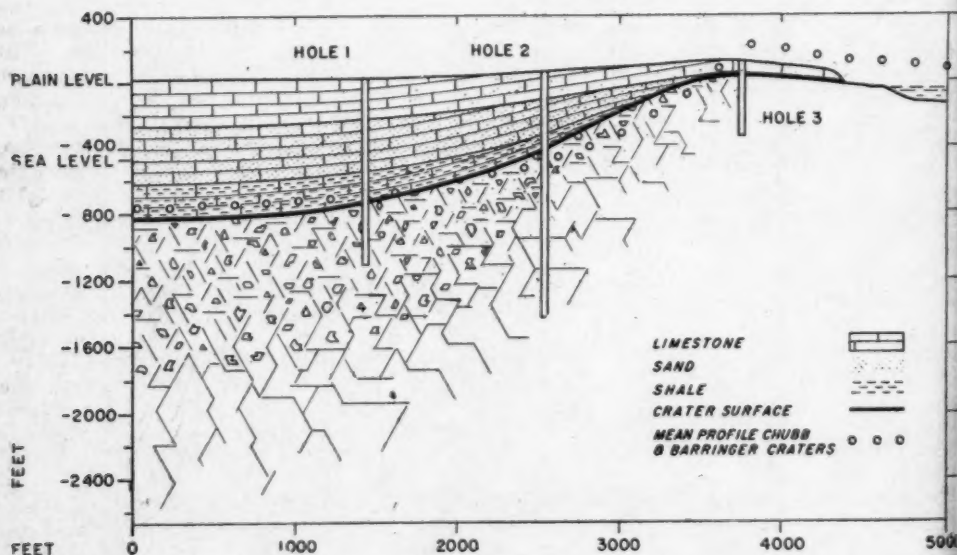


FIG. 9. Profile of Holleford Crater showing comparison with mean of Barringer and Chubb profiles.

The information provided by the drill cores was very favourable to the hypothesis of a meteorite impact origin for the crater. The breccia encountered below the sediments was entirely without bedding planes and gave the impression of being formed in situ by an instantaneous event like an explosion or impact. The shape of the crater as may be seen from Fig. 9 is closely similar to that of the Barringer

and New Quebec craters as well as the theoretical profile of Fig. 2. The information from Hole No. 3 as well as the outcrop of Precambrian rock on the north-east sector of the rim already mentioned gave a definite indication of a rudimentary rim although it is reasonably certain that a large part of the rim was eroded away before the deposition of sediments. No evidence was found that could identify the crater with the processes of erosion, subsidence or volcanism and there appears little doubt that the only reasonable explanation of its origin is that of meteorite impact and explosion (Beals, 1957).

**Search for Meteoritic Material.**—A search for meteoritic material was conducted making use of two different techniques. First all of the drill cores were studied with the aid of a highly sensitive astatic magnetometer and those which showed indications of greater than average magnetic moment were broken up and searched for magnetic particles. In every case it was

found that the excess magnetism was due to pieces of basic rock embedded in the breccia or, in some cases, forming the entire core. In no case was anything suggesting the presence of nickel iron discovered.

A second procedure, carried out with the aid of the Geological Survey of Canada, was to take samples of core every five feet throughout the breccia and to subject them to crushing and

subsequent analysis. In the upper layers of the breccia, the fragments suggested material back into the Palaeozoic. The holes were of inadequate depth to be of any probability of finding meteorite. Age of the surface at the summit of the Black River. Ordovician. The bottom of the sandstone was invaded by Dr. B. of Canada would give 450,000,000 years. Considerable erosion of fragments occurred. It was invaded. Inference is made of the

Following the discovery of the Crater (McGee et al., 1955) Ferguson (Innes, 1955) depression south-east of Saskatchewan. The first in August and geophysical and the section which was obtained by the B. of the results of the preparation (Innes, 1955) appear elsewhere. Deep Bay 56° 24' N, located in the great sea to the south

subsequent magnetic analysis for magnetic particles. In addition to cores from the brecciated layer, numerous cores were taken from the lower layers of the sediments in contact with the breccia since the appearance of these cores suggested that they were formed of finely divided material produced by the explosion and washed back into the crater before the deposition of Palaeozoic sediments. Here again the results were entirely negative and although two drill holes of small diameter are admittedly an inadequate sampling, the possibility or even the probability must be considered that the crater was formed by a stone rather than a nickel iron meteorite.

**Age of the Crater.**—Geological investigations at the surface had indicated the presence of Black River fauna characteristic of the middle Ordovician era. A feature of the core near the bottom of the hole was a layer of whitish sandstone 400 ft. thick which has been identified by Dr. B. V. Sanford of the Geological Survey of Canada as of probably Cambrian age. This would give a minimum age for the crater of 450,000,000 years but it seems probable that it is considerably older. The evidence for the severe erosion of the rim and the absence of Palaeozoic fragments in the breccia suggest that the impact occurred in Precambrian time before the area was invaded by the Palaeozoic seas. If this inference is correct the age of the crater must be of the order of 500 to 1,000 million years.

#### THE DEEP BAY CRATER

Following the discoveries of the New Quebec Crater (Meen, 1950), the Brent Crater (Millman *et al.*, 1951) and the Holleford Crater (Beals, Ferguson and Landau) attention was drawn (Innes, 1957) to a large circular water-filled depression known as Deep Bay, which forms the south-eastern part of Reindeer Lake in Northern Saskatchewan. Two separate field investigations of the feature have been completed, the first in August of 1956 during which geological and geophysical observations were carried out and the second in the winter of 1958, during which additional gravity information was obtained by making gravimeter observations over the Bay on the ice. A complete account of the results of these investigations is in preparation (Innes, Pearson, Geuer, 1960) and will appear elsewhere.

Deep Bay, longitude 103° 00' W, latitude 56° 24' N, elevation 1,106 ft. above sea-level, is located in the Canadian Shield, midway between the great sedimentary basin of the central plains to the south-west and Hudson Bay to the north-

east. Although it lies on the principal route followed by canoes in summer and tractor trains on the ice in winter in freighting supplies to northern outposts, Deep Bay can be reached most easily by aircraft flights from the small settlement at Lac La Ronge, 120 miles to the south, and presently the northern limit of the highway system of Saskatchewan.

Topographically, the Reindeer Lake area is similar to many other places in the Canadian Shield, with flat-topped rock exposures forming hills and ridges above the general level of the lakes, the relief of which seldom exceeds 150 ft. Travelling by canoe, although one might wonder at the wide expanse of Deep Bay (nearly 6¼ miles in diameter), the complete absence of islands and the scarcity of sheltered beaches along its margin, it is unlikely that the near perfect circularity of the bay would be noticed. From an aircraft, flying at considerable height, these unique features are immediately apparent and stand out in marked contrast to the main body of Reindeer Lake, with its numerous islands and irregular bays and shore-lines, which conform in a general way to structural trends of the underlying Precambrian rocks. An aerial mosaic of Deep Bay is shown in Fig. 10.

Although deeply eroded by glacial action, much of the bed-rock portion of the crater's rim remains and stands on the average some 270 ft. above the waters in the bay. To the north-east and east the rim is best preserved. It stands 400 ft. or more above the lake and retains in several places steep and precipitous inner slopes. The original rim diameter is estimated to have been about 40,000 ft. (7.57 miles) or about 1 mile less than its present 8½ miles diameter as marked by the height of land surrounding the bay. As with the Brent Crater the drainage pattern of the Deep Bay area is both concentric and radial, and with the exception of three broad channels into Reindeer Lake along the northern side, the drainage is restricted to short intermittent streams, no greater than two miles in length.

The rocks, which are well exposed in the area, are all granitic in character and are Precambrian in age. Dr. W. J. Pearson of the Department of Mineral Resources of the Province of Saskatchewan has examined the rocks along the shore-line and on the rim and classifies them according to the varying amounts of granitic material they contain. Three main types have been recognized which are as follows: a unit of injection gneisses and migmatites underlying the southern part of the

area, a central unit of metamorphic gneisses of sedimentary origin, and a group of intrusive granitic rocks, chiefly granodiorites and pegmatites which occur along the north-western and northern sides of the bay. Careful examination of the structural relations between these rock types in no way suggests a geological origin for

fracturing and shattering of the granitic rocks which is most pronounced in the vicinity of the shore. Large-scale fracture and fault zones of various widths, now partially obscured by glacial action and deposition, cut radially and obliquely across the rim and persist for several miles from the margin of the bay. A system

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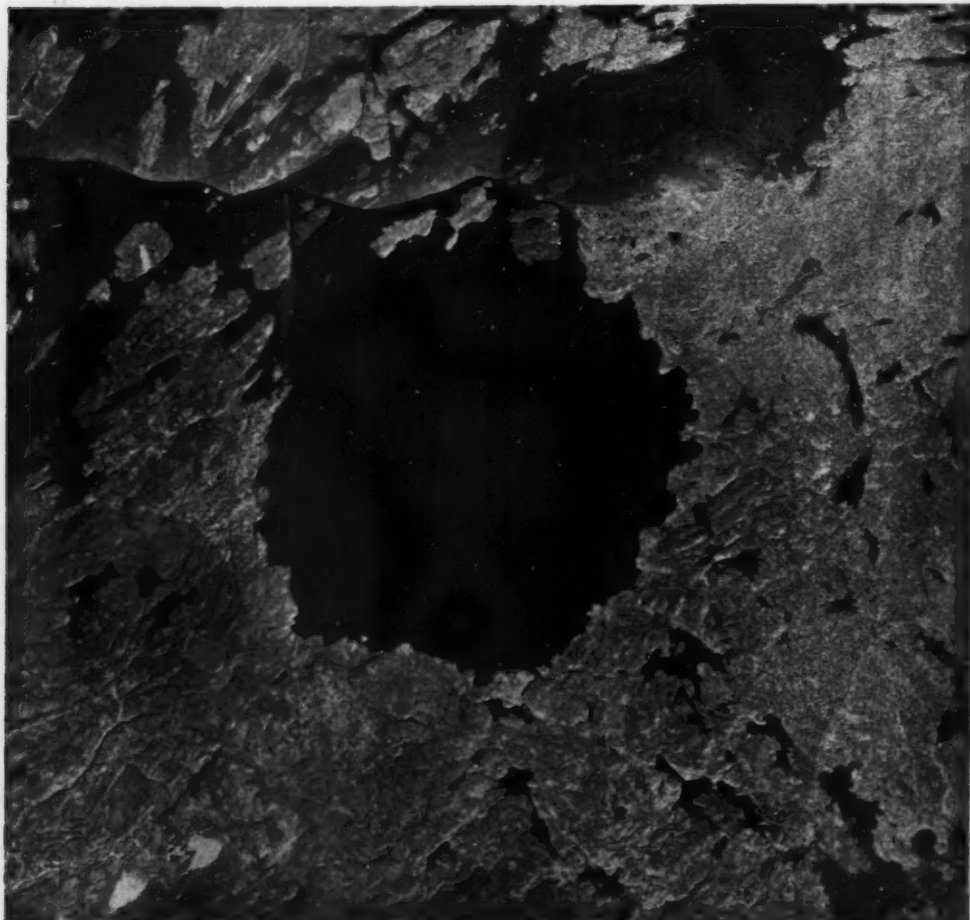


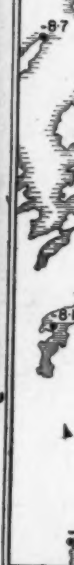
FIG. 10. Aerial mosaic of Deep Bay Crater.

Deep Bay. The general trend of the three units is north-easterly and approximately the same on both sides of the crater, while there is evidence that the strike of many local structures are normal to and are terminated at the margin of the Bay.

That Deep Bay is the result of a tremendous explosion is clearly indicated by the intense

of concentric fractures is also well developed particularly in that area less than 3 miles from the shore-line. Perhaps the most prominent feature, that may be the expression of such fracturing, is a narrow arcuate lake 3 miles in length located about 3 miles to the east of the crater. There is some evidence from the drainage pattern and dissected topography that

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this depressed zone is much longer and circumscribes the whole crater and has a diameter of about 12 miles. Within this area lie the rocks which form the now deeply eroded rim of the crater, with the general appearance of having been shattered into huge blocks by a process involving little or no horizontal movement.

Also strengthening the meteoric hypothesis of origin is the great depth of Deep Bay, when one compares its depth with that of Reindeer Lake, which seldom exceeds 150 ft. Numerous depth recordings show that the present floor of the crater lies at an average depth of about 500 ft. with an extensive depression along the eastern margin of the bay that has a maximum depth of 720 ft. Although outcrops of sedimentary rocks are lacking, boulders and pieces of shale, identified as Mesozoic in age from fossil evidence, were discovered on a small beach near the southern end of Deep Bay. The source of this shale is

uncertain, but as there are no known occurrences of this rock within hundreds of miles, it is believed to have been carried by ice movement from a lake deposit on the floor of the crater. If so, and as 2,100 ft. is the depth predicted to the original plain for a crater of this size, we may expect to find at least 1,400 ft. of sedimentary strata underlying the waters of Deep Bay.

**Geophysical Results.**—So far gravity and magnetic studies are the only geophysical investigations that have been carried out in the Deep Bay area. As found at Brent and Holleford, the gravitational field associated with the Deep Bay Crater is negative (Fig. 11), with contours of equal anomaly forming a circular pattern concentric with the feature. The amplitude of the gravity variation is, however, much larger, reaching a minimum value after corrections for terrain and water depths, of about 20 milligals near the centre of the Bay. The

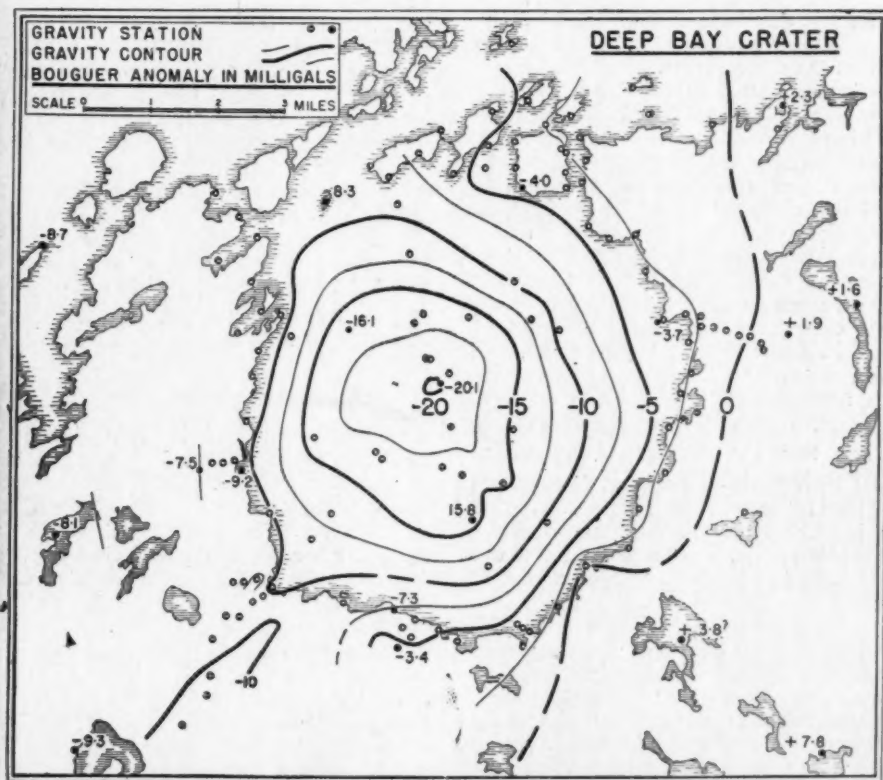


FIG. 11. Gravity contour map, Deep Bay Crater.

1,400 ft. of sedimentary material would account for about 3 to 6 milligals of the total anomaly depending upon its density, leaving the remainder of the anomaly to be explained by the underlying fragmental products of explosion. If the mean density of the latter is similar to the density of the breccia obtained from drill core samples at Brent, which seems reasonable, as the country rock surrounding both craters are granitic gneisses of similar composition and density, it follows that the zone of deformation under the original floor of Deep Bay crater extends to depths which may be as great as 10,000 ft.

An aeromagnetic map of the Deep Bay area has been compiled by the Geological Survey of Canada, giving anomalies in the total magnetic intensity. Because of the more rugged topography the observations were carried out at a flight altitude of 1,000 ft. above general ground level. Although this is twice the height flown during the Brent aeromagnetic survey, the results for Deep Bay are equally definitive and are in qualitative agreement with the results obtained at the other craters.

As before, the most outstanding features of the magnetic map is the small and uniform variation in intensity over the central portion of the crater when compared with the anomalies produced by the surrounding country rocks. As observed at Brent and Holleford the regional field surrounding the crater is highly irregular with local disturbances giving rise to steep gradients and the anomaly contours tending to follow the prominent structural trends of the gneisses. Over the Bay, however, the total variation does not exceed 190 gammas with uniform gradients no larger than 50 gammas per mile, indicative of the great depth to undisturbed basement rocks.

#### OTHER POSSIBLE METEORITE CRATERS

The results of the studies of these three craters are in general agreement with suggestions made earlier in this paper, that the underground structure of a meteorite or explosion crater can retain its identity over a very long period of time after the obliteration of its more obvious surface features. This general conclusion emphasized the necessity, in the examination of aerial photographs, for a careful study of every circular feature which did not have some other clear-cut and definite explanation. During the present survey of Canadian aerial photographs, a great many circular or near circular features were encountered but most of them were discarded as not justifying the expense

and labour of further study. Some were fairly obviously old volcanoes. Others appeared to be sink holes while many shallow circular lakes in boggy ground appeared to be due to the erosional effects of wave action. A number of rather small round lakes may most logically be explained as of the nature of pot holes or solution cavities.

After these more obvious cases had been disposed of (and it is by no means certain that all rejections were justified) there still remained a substantial number of circular features which did not fit in to any standard pattern and for which it appeared legitimate to consider the possibility of a meteorite impact origin. Preliminary studies have been made on the ground for some of these objects but others have been observed only in aerial photographs. Such information about them as is available is summarized as follows:

1. The Franktown Crater, Long. 76° 3-5' W. Lat. 45° 03' N, about forty miles south-west of Ottawa. This feature, about ¼ of a mile in diameter, occurs in Ordovician limestone and may be an example of Type 3, where the buried crater rim, or what is left of it, still influences the attitude of the sediments. The depression is approximately 25 ft. deep and there is a flat area of bog and farm land in the centre which was probably once a lake. The outlines are less clear than at Holleford and in all probability only a diamond drilling program (not yet attempted) would suffice to give a clear indication of the origin of this feature.

2. Clearwater Lakes.—Long. 74° 20' W. Lat. 56° 10' N. These lakes consist of two roughly circular bodies of water separated by a screen of islands. The larger of the two components is 20 miles in diameter while the smaller is 16 miles across. These two circular lakes stand out conspicuously in a region dominated by elongated bodies of water which presumably owe their character to the effects of glacial erosion. An interesting feature of the larger lake is an approximately circular ring of islands, 10 miles in diameter, concentric with the circular lake itself. Some of the islands are of considerable height and this, combined with their circular arrangement, makes them a unique and impressive landscape feature. Geological studies of the islands indicate that they are composed of lava. In default of any other explanation it is thus possible that these two lakes constitute an example of Type 8 and were formed by the impact of twin meteorites, the larger impact resulting in a lava extrusion which took the form of



form of a ring dike. In this connection it is interesting to record that there are several twin craters on the moon roughly corresponding in size to the Clearwater Lakes. Also on the moon there is at least one crater which has a ring dike within it, concentric with the crater as a whole. This crater is 9 miles in diameter, the corresponding figures for the inner ring being 4.5 miles. Apart from size, the similarity to the Clearwater Lake feature is quite striking.

3. *The Manicouagan Lake Feature.*—Long. 68° 37', Lat. 51° 28'. An approximately circular area, enclosed by Lakes Manicouagan and Mushalagan, is a conspicuous aspect of the map of Quebec and many geologists and other students of this region have speculated as to its origin. The circle is approximately 40 miles in diameter and a mountain approximately 3,000 ft. high rises in the centre. Geological studies of the area (Rose, E. R., 1955) indicate that the central mountain is an igneous intrusion and that otherwise a large part of the area is covered by flat lying lavas of somewhat different character. The possibility has been considered that this may represent an example of Type 8 where a large crater has had its rim removed by erosion leaving the central mountain plus a lava floor. Some geophysical studies have been made in the region but the size of the area and the complicated nature of its geology has so far prevented any definite conclusion.

4. *Stratified Circular Features in North-eastern Quebec and Labrador.*—Aerial photographs in this general area have revealed five circular features ranging from 2½ miles to 7 miles in diameter which exhibit a stratified appearance somewhat similar to that shown by the Holleford Crater. The stratified structures in some cases stand up somewhat above the surrounding plain. It is considered possible that they represent examples of Type 5 where an ancient crater has been filled with sediments which have subsequently been consolidated to the extent that they retained their identity when the surrounding rock has suffered severe erosion. The locations and diameters of these features are given in Table I.

5. *Circular Structure, Carswell Lake Area, Saskatchewan.*—Long. 109° 30', Lat. 58° 27'. During the geological field season of 1957, W. F. Fahrig of the Geological Survey of Canada, working in Northern Saskatchewan, discovered a feature approximately 18 miles in diameter bounded on its circumference by

TABLE I  
Stratified circular features

General area	Longitude	Latitude	Diameter (miles)
Mecatina Crater*	59° 22'	50° 50'	2
Lake Michikamau	64° 27'	54° 34'	3½
Menihik Lake	66° 40'	53° 42'	3
do.	67° 10'	54° 19'	2½
Sault au Cochons	70° 05'	49° 17'	7

\* Illustrated in Fig. 12.

co-centric circles of rock outcrops consisting of sandstone and dolomite sediments. These sediments, considered to be of Precambrian age, were deformed and tilted in a manner somewhat reminiscent of those on the rim of the Barringer crater designated as Type 6. According to a sectional diagram provided by Dr. Fahrig, the strata give the impression of having been compressed along a radius and tilted more than 90° away from the centre of the feature. Since this is the kind of deformation expected for a meteorite crater formed in sedimentary rock this feature is considered as having a possible meteorite origin. It is hoped to carry out some geophysical tests of this hypothesis during the 1960 field season. Although the writers consider that the available evidence is best satisfied by the meteorite impact hypothesis, it should be emphasized that there are other explanations which Dr. Fahrig, the discoverer, regards as more probable.

6. *The Nastapoka Islands Arc of Hudson Bay.*—Long. 80° 02', Lat. 57° 40'. These coordinates represent the centre of curvature of an almost perfectly circular arc on the east coast of Hudson Bay, approximately 275 miles in diameter. This is a conspicuous feature even on a world map and many scientists and others have made the suggestion that it might have been due to the impact of a giant meteorite.

On a moderately large-scale map it is seen that over most of its length the arc is characterized by a screen of off-shore islands of which the most important are the Nastapoka Islands, a chain over one hundred miles long of average latitude 57°. Geological studies of the Islands (Bell, R, 1877-78; Low, A. P., 1900; Kranck, E. H., 1950) have indicated that they are composed of Precambrian sediments, which sometimes extend to the mainland and throughout the length of the arc the sediments dip radially inward toward the centre at angles of a few



FIG. 12. Aerial view of Mecatina Crater. This may be an ancient crater filled with sediments later transformed into gneiss.

degrees. Studies of aerial photographs have confirmed the radial direction of dip over the entire length of the arc and they have also confirmed that in many places the sediments extend to the mainland where it is often possible to see the contact between the sediments and the granitic rock of which the mainland is largely composed. When observed from a low flying aircraft, the seaward dip of the sediments is a very striking phenomenon and, considered in connection with the above geological and photographic evidence, suggests the existence of a deep circular basin in which great depths of sediments may well have been deposited. In addition to the off-shore islands already mentioned, there are numerous other islands nearer the centre of the circle of which the

most important are the Belcher Islands south and east of the centre. Where geological information is available the islands are composed of Precambrian sediments often capped or interbedded with lava flows. It appears that in contrast to observations on the border of the arc, the sediments on the more central islands are in general either flat lying or folded and do not correspond in dip to those on the arc (Jackson, G. D., Private communication). In addition to the evidence for volcanism on the islands, lava flows are also a feature of certain areas of the mainland near the coastal arc.

On the landward side of the arc, hills normally rise to a height of several hundred feet; in places near Richmond Gulf the elevation is 1,500 ft. above sea-level and this is suggestive

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of an ancient and eroded crater rim. The incompleteness of the circle on the west is of course a handicap to interpretation and at present there is no evidence of a continuation, under water, of the visible features of the arc. It may be remarked however, having regard to the very great age of the feature (600,000,000 to 1,000,000,000 years) that it would indeed be surprising if it had remained completely intact over such an immense period of time. If this is truly a fossil meteorite crater we are fortunate in having such a substantial proportion of it remaining for study.

There is a rather striking parallel between this feature and the well-known feature known as Mare Crisium on the Moon. Mare Crisium is an oval to circular feature of average diameter 318 miles and depth 8,000 ft. with what is believed to be a lava floor. Although measures of altitude are not available for the rim it is clear that the feature is surrounded by hills which rise to a height of several thousand feet. When the phase of the moon is such that the sunlight terminator bisects Mare Crisium its resemblance to the Hudson Bay arc is quite striking. Unfortunately the size of the Hudson Bay feature and its great age are formidable obstacles to investigation. It would appear logical to look for a lava floor under the sediments but their assumed great depth (3,600 ft. near the coast and presumably much greater further out) would make drilling very expensive. It is also quite probable that consolidation and alteration of the sediments would make it difficult by geophysical methods to establish the existence of a boundary with the basement. In spite of these difficulties it is hoped to undertake gravity, magnetic and seismic work in the area as soon as facilities are available for making measurements of this kind at sea.

7. *Gulf of St. Lawrence Arc.*—Long. 63° 03', Lat. 47° 00'. A configuration somewhat similar to the Hudson Bay arc though smaller (180 miles in diameter) is outlined by parts of the coast-lines of Nova Scotia and New Brunswick in the Gulf of St. Lawrence. Prince Edward Island and the Magdalen Islands lie within the circle and the somewhat roughly outlined arc subtends a sector of over 180°. Seismic observations within the circle have indicated the presence of sediments of a depth of approximately 6 km. This result is not unfavourable to the meteoric hypothesis but much more extended observations will be required before it will be possible to reach any definite conclusion.

8. In addition to the circular features described above there are a number of circular lakes or bays scattered throughout Canada which for one reason or another (e.g., excessive depth, evidence of shattering around the shore-line or simply unexplained incongruity with their surroundings) are listed as possibilities in the continuing search for old craters. These include Lac Couture, Long. 75° 20', Lat. 60° 08', diameter 10 miles; West Hawk Lake, Long. 95° 12', Lat. 49° 46', diameter 3 miles; Keeley Lake, Long. 108° 08', Lat. 54° 54', diameter 8 miles and Ungava Bay, Long. 67° 20', Lat. 60° 00', diameter 150 miles.

In listing these features and the ones described under 1 to 7 above it should be very definitely understood that they represent interesting possibilities worthy of further investigation but cannot yet be presented as probable fossil craters to be included in the statistics of earthly as compared to lunar features. It will no doubt be many years before the true nature of these objects is fully understood. In the meantime it is hoped that publicizing the locations will encourage the necessary investigations by geologists, geophysicists and others interested in meteoritic phenomena.\*

*Cryptovolcanic Structures.*—Any discussion of fossil meteorite craters would be incomplete without some mention of cryptovolcanic structures since it was in connection with these fascinating objects that the actual existence of fossil craters was first suggested. The term cryptovolcanic was first used by Branca and Fraas (1905) in connection with the Steinheim Basin (Long. 10° 04' E, Lat. 48° 1.5' N) in Southern Germany. This feature, which is typical of other similar objects of various sizes is a ring-shaped depression 1½ miles in diameter with a present depth of approximately 260 ft. below the surrounding plain. In the centre of the structure is a low hill 130 ft. high on the slopes of which part of the town of Steinheim is located. Much of the feature is obscured by the deposition of sediments (both consolidated and

\* *Lunar Lake*:—Lunar Lake in India (Long. 76° 51' E, Lat. 19° 59' N) is a circular feature slightly more than a mile in diameter and 400 ft. deep. Geologists who have examined it have attributed it to a volcanic explosion but specific evidence for volcanism appears to be lacking. Its circular form and raised rim suggest a meteorite impact origin and it may well be due to this cause.

See Medicott and Blandford, *A Manual of the Geology of India*, Part 1, 1879.

Blandford, *Records of the Geological Society of India*, 1870, 1, p. 63.

Newbold, *Journal of the Royal Asiatic Society*, 1846-48, 9.

unconsolidated) but the essential features seem to be (1) the ring-shaped depression, (2) the central hill, the rocks of which appear on the basis of geological evidence to have been carried some 500 ft. above their normal level in disordered and shattered blocks, (3) intense brecciation extending to the outer edge of the disturbance. In suitable exposures the beds are seen to be broken and tilted in diverse directions and in places are so completely shattered that every trace of original bedding is lost.

Although no traces of volcanic materials have been reported it has been generally assumed that this and similar features later discovered by Bucher (1933) are due to concealed volcanic explosions, hence the term cryptovolcanic structure. Locations and diameters of circular features resembling the Steinheim Basin are shown in Table II.

TABLE II  
Cryptovolcanic structures

Name	Location	Diameter (miles)
Steinheim Basin ..	10° 04' E, 48° 1-5' N South Germany	3
Ries of Nordlinger	10° 37' E, 48° 53' N South Germany	15
Jeptha Knob. ..	85° 6-8' W, 38° 6-4' N Kentucky, U.S.A.	2
Serpent Mound ..	83° 25-2' W, 39° 1-7' N Ohio, U.S.A.	4
Upheaval Dome ..	109° 56-6' W, 38° 27-7' N Utah, U.S.A.	3
Wells Creek Basin	87° 39-5' W, 36° 23' N Tennessee, U.S.A.	6
Flynns Creek Structure	85° 37-4' W, 36° 16' N Tennessee, U.S.A.	2
Decaturville Struc- ture	92° 4-5' W, 37° 53-8' N Missouri, U.S.A.	Un- certain
Kentland Structure	87° 23-5' W, 40° 45-4' N Indiana, U.S.A.	do.
Crooked Creek Structure	91° 23' W, 37° 50' N Indiana, U.S.A.	3

While there is a good deal of diversity among these various objects, investigation of those discovered in the United States indicate that in general they depart somewhat from the circular form and this quality of asymmetry may have something to do with their origin. Another indication which may also be diagnostic is the existence of an outer ring which, with the inner circular depression, has been compared to a system of damped waves associated with an explosion.

The suggestion that the original disturbance which formed what is now the Steinheim Basin

was the impact of a meteorite was originally put forward by Rohleder, H. P. T. (1933). Later Boon and Albritton (1936, 1937, 1942) discussed the character of the underground structures likely to be formed by meteorite impact and suggested that cryptovolcanic structures were the remains of ancient meteorite craters. Similar views were put forward by Dietz (1946) and Baldwin (1949) in their classic work on lunar and terrestrial craters. More recently, as a result of geological investigation and drilling at the sites of the Wells Creek Basin, the Kentland structure and the Crooked Creek structure, Wilson (1953), Dietz (1959) and Hendricks (1954) have concluded that some, if not all, of the cryptovolcanic structures find their most logical explanation in meteorite impact. Wilson has called attention to the presence of large quantities of rock breccia and to massive deformations of sedimentary beds around the margins of the Wells Creek Basin and the Flynn's Creek structure in Tennessee, while Hendricks has found similar evidence in connection with the Crooked Creek structure in Missouri. In addition Wilson has had the opportunity to log a diamond drill hole 2,000 ft. deep in the centre of the Wells Creek Basin where he found ample evidence of brecciation and fracturing but no indication of volcanic action. Dietz has examined most of the known cryptovolcanic structures in Europe and North America and has found shatter cones associated with them indicating that the impact which caused them came from above rather than below.

*Comparison of Impact and Volcanic Hypotheses on the Basis of Pressures Involved.*—Of special interest in connection with cryptovolcanic structures is a comparison of the physical effects from a meteorite explosion and the explosions associated with the build-up of steam and magmatic pressures where volcanic activity is at hand.

The basic fact is that in the meteorite impacts, as in the underground nuclear detonations, the stress wave communicated to the ground starts off with pressures of many megabars (10<sup>6</sup> atmospheres). Such pressures are not attained lithostatically in the Earth except at depth of 2,500 km. or more below the surface (Bullen, 1947). In other words for a steam or magma explosion to build up to the pressures comparable with that of a meteorite striking at a speed of 10-30 km./sec. (Whipple, 1955) would make it possible to lift the whole of the Earth's mantle. It is clear that any such volcanic activity occurring near the Earth's surface would have vented



long before the pressure reached these values. (Even at the depth of the Mohorovicic layer the lithostatic pressure is only a few per cent. of a megabar.)

It follows that the identifiable features of a meteorite explosion, i.e., pressures capable of producing physico-chemical phase changes near the point of impact and crushing and fracturing at increasing radial distances from the centre should be distinguishable from those in the neighbourhood of volcanic pipes. In particular it appears that for volcanic explosions both theory and observation indicate that intense brecciation is pretty well confined to the area of the vent where the explosive volcanic forces burst through the Earth's surface and does not as in the case of meteorite impact, extend into the country rock to distances of the order of 10-20 times the diameter of the exploding body. It seems probable therefore that detailed gravity observations combined with diamond drilling techniques should eventually make possible a definite decision as to the origin of cryptovolcanic structures.

#### SUMMARY

Summarizing the results to date of the search for fossil meteorite craters, the most important advance is clearly the establishment with a high degree of probability of the existence of three fossil craters of large size and sufficiently great age to justify the belief that others are likely to be found if a sufficiently exhaustive search is made for them. Secondly the location of a considerable number of circular features in Canada, for which no other explanation has been found, leads to hopes that at least some of them may turn out to be the result of meteorite impact. Thirdly recent evidence suggesting a meteorite origin for certain cryptovolcanic structures in the United States emphasizes how important it is to make further investigations of these enigmatic objects. While it may be that not every feature classified as cryptovolcanic is due to the same cause, nevertheless, if by diamond drilling and geophysical techniques a definite positive or negative result could be obtained for a representative selection of these objects, it would do a great deal to clear the air in the further search for fossil craters.

Finally the results of the study of aerial photographs has clearly indicated that the best hope of future progress in this field is the extension of a systematic search over as large an area of the Earth's surface as possible. The wide aerial photographic coverage which now exists in many countries, and which is being

rapidly increased, represents a golden opportunity to make a decisive contribution to this branch of astronomical-geophysical science. It is to be hoped that astronomers and others interested in this problem will make increasing use of this opportunity to extend our knowledge in a field which is important not only to the early history of the Earth, but also to a clearer understanding of the physical relationships between members of the solar system.

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#### NATIONAL PHYSICAL LABORATORY (ENGLAND): ANNUAL REPORT FOR 1959\*

THE wide range of research topics in modern physics covered by the work of the NPL is described in the latest Annual Report of the Laboratory.

In the new Basic Physics Division the programme has been aimed at investigating different aspects of the Physics of polymers, by means of the most modern techniques for examining the atomic structure of matter. Success in understanding how the atoms are held together in plastics and other polymers, and how these arrangements of the atoms define their mechanical, electrical and thermal properties would have far-reaching consequences.

The programme of the Aerodynamics Division covers many aspects of research of importance to future aircraft and missile design and development. The phenomena of buffeting and aileron buzz, which decrease the safety and controllability of aircraft when they occur, have been studied. As a result means of suppressing these effects have been suggested.

The Standards Division has continued to foster international collaboration in several fields. Determination of the density of mercury

has been completed by measurements on samples from the standards laboratories of Australia and the US. A start has been made on correlating UK and US time and frequency services. The scale of temperature between 10° K and 90° K defined by the platinum resistance thermometer has been related to the thermodynamic scale by means of a helium gas thermometer. Comparisons are being made with the US and Russia, with the intention of extending the International Temperature Scale below its present lower limit.

Spectro-radiometric methods have been tried successfully by the Light Division for the first time in the establishment of the standard scale of colour temperature.

The Metallurgy Division which is now equipped with some of the best modern research tools available for the study of metals (including an electron microscope, soft X-ray spectrograph, mass spectrograph and optical spectrograph), is bringing these modern techniques to bear on some of the problems associated with precipitation processes in iron. It is now possible, by using the electron microscope, to see dislocations (i.e., the faults in the atomic planes which weaken metals by one hundred to a thousand times).

\* Report of the National Physical Laboratory, 1959, printed for D.S.I.R. by H.M.S.O., Price 8s. 0d.



## INFRA-RED AND RAMAN SPECTROSCOPY

**A**N International Course on infra-red and Raman Spectroscopy was held under the direction of Prof. Dr. A. Simon at the Institute of the Technical College in Dresden in co-operation with VEB Carl Zeiss JENA. Thirty scientists from Czechoslovakia, Hungary, Rumania and the German Democratic Republic took part. The programme included 17 lectures with relevant practical work dealing with theoretical and practical principles of infra-red and Raman spectroscopy, also with instrumental problems especially questions concerning the All-Automatic Infra-red Spectrophotometer UR 10 made by VEB Carl Zeiss JENA. In his introductory lecture on "Raman and Infra-red Spectroscopy Complementary Methods" Prof. Simon illustrated with examples how the two methods complement each other and how appropriate it is to discuss them both together. The theme of the course was based on this point of view. Dr. Kriegsmann, Dresden, spoke about Instruments for Raman Spectroscopy, giving a survey of the present state of Raman technique and details of the design of powerful Raman sources. He also held lectures on the "Nature of Characteristic Frequencies", "Qualitative Analysis and Purity Testing" and "Vibration Spectra of Physical and Chemical Properties". In yet another lecture he dealt with the principles of Intensity Measurement and then gave information about the accuracy attainable in practice. Dr. Stegar, Dresden, spoke about "Symmetry and Selection Rules", "Problems of Solvents in Infra-red Spectroscopy" and "Intermolecular Effects". Dr. Paetzold, Dresden, gave a systematic description in his lecture "Techniques for Solid Materials" of all preparation methods occurring in infra-red spectroscopic investigations of solids. The two lectures "The Importance of Infra-red Spectroscopy in Industry with Particular Attention to Composition Determination" by Dr. Fruwert, VEB Leuna-Werke, and "On Quantitative Analysis" by Dr. Kimmner, VEB Chemische Werke Schkopau, gave some examples of the industrial application of infra-red spectroscopy. Members of VEB Carl Zeiss JENA Staff held the following lectures: Dipl.-Phys. Kramer on "Characteristic Properties of an Infra-red Spectrophotometer which are typical of the state of development and efficiency of modern infra-red instruments. Ing. G. Pohl discussed the Technico-Physical Properties of the UR 10

and their Testing and gave hints to the users of control measurements with the UR 10. Dipl. Ing. Gunther lectured on the Limitation of Errors and Elimination of Errors in the Electronic and in the Servo System of the UR 10. Dipl.-Phys. Buttner spoke about recently designed Ancillary Instruments for the UR 10, for the Measurements of Liquid, Gaseous and Solid Substances, which were introduced to users of the UR 10 for the first time at the Course. They are the Variable Space Liquid Cell, the Long Path Gas Cell, the accessories for the KBr-pressing technique (vibrator, press and press tool) and the single beam device for the UR 10. The Practical Work was held in 6 groups consisting of 4-5 people, a scientific assistant of the institute as Group Leader and for experiments with the UR 10 of a member of the Zeiss staff for explaining any problems related to the instrument.

Characteristic examples of qualitative and quantitative analysis, the determination of composition, purity testing as well as the required preparation and photographic technical methods of infra-red and Raman Spectroscopy were elaborated. The new attachments for the UR 10 were also used, giving participants of the course a direct opportunity to become familiar with the efficiency of these instruments. In the Instrument-Practical Work Testing of the Technico-Physical Properties of the UR 10 and Error Limitation in the Servo System and in the Electronics of the UR 10 the use of the single beam device for the UR 10 was explained and demonstrated in detail. The possibilities offered to the user by this device with regard to speedy control of the functions of the UR 10 evoked greatest interest of all those present. Foreign colleagues were particularly anxious to get to know more about the functions of the UR 10 and their control in order to carry out in future small adjustments to the instrument themselves. In addition this work gave valuable advice for the correct operation and appropriate application of the instrument.

Great interest existed also in the new Photoelectric Recording Photometer Lirepho 2 with Compensating Recorder, which was used for Raman Spectroscopy.

Discussions showed that this first course on infra-red and Raman Spectroscopy fulfilled the expectation of those participating, as theory and practice as well as prerequisites relating to instruments were dealt with in correct proportion.—*Courtesy, JENA Review.*

## LIVING MOLECULES\*

DR. M. F. PERUTZ

Cavendish Laboratory, University of Cambridge, England

SCHOOL text-books of biology taught me that living cells are filled with protoplasm. At the University I was led to believe that protoplasm was a suspension of colloids, large molecular aggregates of indefinite structure which somehow endowed it with life. Today we realise that these names were mere repositories of ignorance and that protoplasm is really a microcosm of vast complexity and definite molecular structure. We are still extremely far from knowing this structure in detail, but we are beginning to understand some of the basic facts of reproduction, growth, breathing and movement in molecular terms.

Growth is essentially a process of chemical synthesis, and to understand it we must know how it is directed and controlled. The cell cannot work under the extreme conditions of temperature and pressure used in a chemical factory. Instead, it synthesises its constituents in a series of small chemical steps, each brought about by a specific chemical called an enzyme. Several thousand such enzymes are probably required to bring about all the diverse processes on which life depends. Well over 1,000 different enzymes are already known, and all those which have been isolated were found to be complicated substances of the type known as proteins. This makes the determination of the way in which proteins are built one of the fundamental problems in biology and medicine.

## CONTROLLING LIFE CELL

If proteins are the enzymes which control the life of the cell, what controls the synthesis of the proteins? It cannot be other enzymes made of protein, since they would have to be made by yet more enzymes, and so on *ad infinitum*. We now know that the synthesis of enzymes is controlled by genes—the material which passes from generation to generation and determines inherited characteristics.

A gene must therefore possess a dual function: it must be able to copy itself exactly, so as to pass the message to the next generation

and it must be able to determine the structure of a protein or a protein molecule.

The genes of nearly all organisms consist of a material which has been called deoxyribonucleic acid or DNA for short. This DNA is so made as to form a chemical code. Its molecules consist of long chains of atoms in which an identical chemical pattern of sugar and phosphate repeats at regular intervals like the links of a chain.

Attached to each link is a rather complicated group of atoms called a base. There are four different kinds of base. We do not yet know in what order they are arranged in any one nucleic acid, nor have we any direct information that they are arranged in any definite order at all; we know only that their proportions are constant and characteristic in the DNA from any particular species.

It is the fact that the bases are the only variable constituents which makes us believe that they are arranged in a definite order and that this sequence is the "code" which carries the inherited information. If this is true the genetic language is written in a four-letter alphabet on an immensely long scroll. The actual number of "letters" in the DNA of bacterial virus is 500,000 and in the chromosomes of a mammal about 3,000,000,000.

## CONTINUITY OF INHERITANCE

To ensure continuity of inheritance an exact copy of this information has to be made each time a cell divides. In 1953, J. D. Watson and F. H. C. Crick at the Medical Research Council Molecular Biology Research Unit at Cambridge proposed a structure for DNA which suggests a possible copying mechanism (Fig. 1).

It consists of two chains of DNA coiled round each other, like two snakes, to form a double helix. The actual model looks like a spiral staircase in which the links of the nucleic acid chain form the banisters, and the bases attached to them form the steps. Each step consists of two bases, one from each of the chains, which are linked together by chemical bonds.

Suppose now that the four bases which form the symbols of the genetic code are called A, T, G and C, then only specific pairs of bases can be linked to form a step, such that A is always linked to T and G to C. This means

\* This article is specially written by a leading scientist in Britain to mark the 300th Anniversary of the Royal Society in July 1960. The Royal Society—or to use its full title, "The Royal Society of London for the Promotion of Natural Knowledge", received its first Charter from King Charles II, who also described himself as its founder and patron.

FIG. 1. A model of the phosphate bases by distance = 1/10,000,000 inch. (One angstrom atom. the atomic structure in the staircase" a reproduction of the present double helix solution form to have to become new complex

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This means joins on to the main link can be linked to form a step, such that A and so

that a particular sequence of bases in one chain must be paired to a complementary sequence in its partner chain. Wherever A appears in one chain T must be in the other, not A, G or C. This is the vital idea of Watson and Crick's model, for from it we can deduce the way in which the genetic code might copy itself.

When we want to copy a document we prepare a negative from which we make a positive print. The complementary sequence of

links are joined, each parent chain will be intertwined with a new daughter-chain made up of a complementary sequence of bases. In this way one parent double helix gives rise to two daughter double helices each carrying on an exact copy of the genetic information.

We do not yet know how nucleic acids control the synthesis of enzymes. Certain parts of the mechanism have been discovered and others are still obscure, but almost every month some new observation is published in the scientific literature which adds a new piece to this great jigsaw puzzle.

Great progress has recently been made in Britain in elucidating the structure of the proteins themselves. Like the nucleic acids, proteins are giant molecules made up of molecular chains, but whereas DNA has only four different groups attached to the links of the chain, proteins possess 20 and these are called amino-acids. Like the nucleic acids, protein chains tend to take up helical configurations.

One protein may consist of one or several such chains, which in turn may contain anything from 20 to several thousand amino-acids, so arranged that the different kinds of side-chains occur in a definite order. This sequence is the translation of the genetic code into protein structure. Ten years ago the structure of protein was still largely unknown. In November 1958 the Nobel Prize for Chemistry was awarded to F. Sanger, a member of the Medical Research Council's Staff at Cambridge University, for having been the first to work out the chemical constitution of a protein, by determining the order of the 51 amino-acids in the two chains composing the molecule of insulin.

#### CHEMISTRY MILESTONE

This discovery was one of the milestones in protein chemistry. First, it removed the last shadow of doubt from the protein chain hypothesis which Hofmeister, a German Chemist, had enunciated more than 50 years earlier. It established the fact that the different amino-acids really are arranged in a definite, genetically determined sequence, but disproved the widely held belief that this sequence was regular. It revealed the part played by sulphur bridges in the architecture of protein molecules, and the chemical nature of the differences between animal species. Most important of all, Sanger demonstrated that the complete formula of a protein can be determined by chemical methods and thereby stimulated a great new volume of research all over the world.

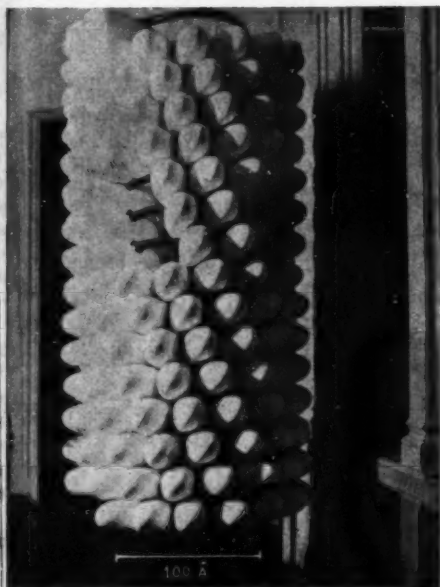


FIG. 1. A model of a double helix structure of DNA. The phosphate-sugar links are represented by wires and the bases by disks. The scale indicates Ångstrom units.  $1\text{ Å} = 1/10,000,000$  of a millimeter or  $1/250,000,000$  of an inch. (One and a half Ångstroms is the size of a single carbon atom. The Ångstrom is the unit of measure in the atomic scale.)

bases in the two chains makes each DNA "staircase" a negative and positive combined. To reproduce themselves the two chains of the parent double helix would have to separate in a solution full of loose links similar to those which form the chains, and each chain would have to become a template for the building of a new complementary chain which grows around

#### MONTH-BY-MONTH INFORMATION

This means that a loose chain link carrying T joins on to T in the parent chain, a loose chain link carrying G joins on to C in the parent chain and so on. When all the loose chain

The problem of protein structure really required a two-fold approach: the chemical one, used by Sanger to find the number of chains and the sequence of amino-acids, and a physical one to discover the way the chains are coiled and folded. The physical approach is based on X-ray analysis. It involves studies of the X-ray diffraction patterns, generally from single crystals, and is a technique that has been widely used to determine the atomic arrangement in simpler compounds. Most of these compounds, however, were at least 100 times smaller than protein molecules, and it was a matter of great difficulty to extend the methods of X-ray analysis to molecules of such enormous size and complexity. None of the approaches yielded much information, until I discovered, in 1953, that the problem could be solved by studying the X-ray diffraction patterns from a pair of crystals, one containing the protein alone and the other a derivative of the protein incorporating a heavy atom such as mercury. This method has now become the basis for the structural analysis of crystalline protein and viruses in many laboratories.

Its first great success was achieved in 1957 when my colleague J. C. Kendrew was able to build a three-dimensional model of myoglobin, a protein containing pigment group called haem to which the oxygen becomes attached. The first X-ray analysis was calculated with a limited power of resolution, sufficient to show the general configuration of the chain and the position of the haem group, but incapable of resolving atoms.

#### NEW X-RAY ANALYSIS

Late last year Kendrew and his collaborators completed a new X-ray analysis at three times the resolution of the first, which shows the structure in almost atomic detail. The straight stretches of chain in Fig. 2 are now resolved into helices like right-handed screws. These make up about two-thirds of the structure. Departures from the helical configuration occur mainly where the chain bends or turns a corner.

The manner of linkage of the haem group to the chain, which has long been a matter of great interest to biochemists, is well resolved. As we expected, the link is made through the nitrogen atom of an amino-acid side-chain called histidine which forms a chemical bond with the iron atom in the haem group.

My own work is concerned with haemoglobin, the protein in the red-blood cells which carries oxygen from the lungs to the tissues and carbon

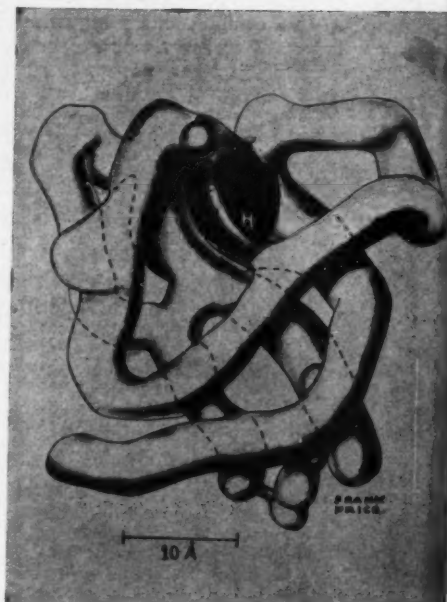


FIG. 2. J. C. Kendrew's model of the myoglobin molecule. The light winding rod represents the protein chain, the dark disk the haem group.

dioxide back to the lungs. It contains about 10,000 atoms and consists of four chains each with about 140 amino-acids, and four haem groups, each capable of carrying one oxygen molecule. The result of an X-ray analysis carried out by several colleagues and myself show that each of the four chains is bent in the same shape as the chain in myoglobin. The four chains are then assembled at the corners of a tetrahedron and together make up a molecule which is very nearly a sphere. The vital important haem groups lie in separate pockets at the surface of the molecule, each pocket being formed by the folds in one of the chains.

#### COMPLEX STRUCTURE

How is the enormously complex structure of this molecule related to its function? It serves to carry four molecules of oxygen, minute in size by comparison, from the lungs or gills to the tissues. Each oxygen molecule is attached to one haem group. It is one of the vital physiological properties of haemoglobin that the haem groups interact, so that the combination of the first one with oxygen makes it easier for the next one to combine, and so on. The present model is sufficiently detailed to

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out some wrong theories which were current to explain these interactions, but not yet detailed enough to tell us the right explanation. This may come at the next stage of the analysis when we hope to work out most of the structure of haemoglobin in atomic detail.

X-ray analysis can be applied to any crystalline substance, no matter how big its molecules, including some of the smaller plant and animal viruses which can be crystallized like any chemical and are yet in a certain sense alive. They contain millions, rather than thousands, of atoms.

X-ray work on the mosaic virus, which causes mottling in the leaves of the tobacco plant, was started at Cambridge University by J. D. Bernal and I. Fankuchen in the late 30's and has been continued in the past decade by D. Casper in the United States and by J. D. Watson, Rosalind Franklin and A. Klug in this country. As a result of their work we now know that the virus is a rod in which nucleic acid and protein are interwoven in a beautiful pattern (Fig. 3). A helical chain of nucleic

ponents of the virus only the nucleic acid is infective. It acts as the gene which reorganises the infected tobacco leaf cell for the purpose of producing virus, while the protein seems to be merely a protective coat for the gene. On the atomic scale their size is truly gigantic and yet their structure is almost as definite as that of a molecule of sugar, where every atom occupies its rightful place.

#### STRUCTURE OF MUSCLE

Movement is one of the most important manifestations of life. How is it accomplished on a molecular scale? The answer to this question has not yet been found, but it has been brought much nearer by the work of H. E. Huxley and Jean Hanson at London University, and of A. F. Huxley and F. Niederganke at Cambridge University, who have studied the structure of muscle by a variety of techniques, especially electron microscopy.

Muscle contains two kinds of protein filaments which are known as myosin and actin. In most muscles, like those of the arms and legs, these filaments are arranged in a series of bands, visible under the microscope at striations one two-thousandth of an inch wide, which runs across the length of the muscle. The myosin filaments are arranged in parallel so that each one is surrounded by six others at the corners of a regular hexagon. At the centre of each triangle formed by three myosin filaments is a filament of actin. Changes in the length of the muscle are achieved by the actin filaments sliding into or out of the spaces between the myosin filaments. By an ingenious choice of material Jean Hanson and J. Lowy at the Medical Research Council's Biophysics Research Unit at London University, were recently able to show that the mechanism of contraction in the slower-acting, smooth muscle, like that of the uterus, is essentially the same as in striated muscle.

Sliding motion between two different kinds of protein filaments may well turn out to be the universal mechanism of movement throughout the animal kingdom. It gives a picture of movement on the sub-microscopic, but not yet on the molecular scale, and leaves the chemical forces responsible for sliding between the two kinds of filaments still to be discovered. This will be the next great step in muscle physiology.

The greatest advances in our understanding of biological function are likely to come through a knowledge of structure on the molecular scale. Recent work in Britain has contributed significantly towards this aim.

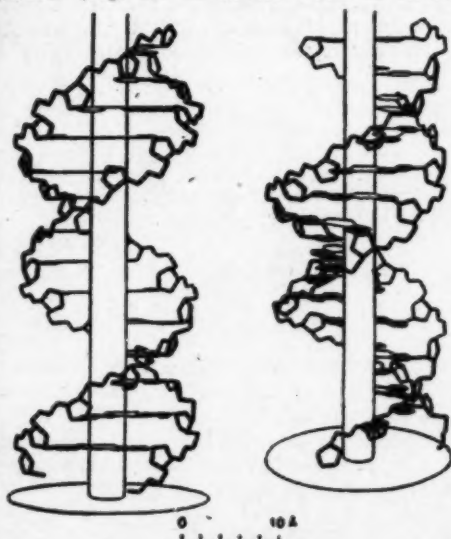


FIG. 3. A model of tobacco mosaic virus. Each "loaf" represents a protein sub-unit of molecular weight 17,000. Seen in detail it would look somewhat like the model in Fig. 2. The opening shows the coils of RNA inside the particle. The Pitch of the coil is 23 Å. (Rosalind Franklin and A. King).

acid is wound around a central cylindrical hole like the filament of an electric lamp, and is surrounded by a helical array of 2,000 protein molecules all exactly alike. Of the two com-



## LETTERS TO THE EDITOR

RADIATION: GRAVITATIONAL AND  
ELECTROMAGNETIC

PIRANI<sup>1</sup> has recently formulated the definition of gravitational radiation in an invariant way by making two assumptions: (1) gravitational radiation is characterised by the Riemann tensor and (2) radiation must be propagated along the null cone. Since electromagnetic radiation is also being propagated along the null cone, quite a large amount of similarity is obtained in the mathematics that is to be used to describe the propagation of the two types of radiations. As a matter of fact, while working with axially symmetric electromagnetic fields of pure flowing radiation in the scheme of general relativity we come across a number of cases in which when the electromagnetic radiation is switched off, one is left with gravitational radiation flowing in the same wave pattern. The object of this note is to discuss one such simple case.

We have proved elsewhere<sup>2</sup> that in the field of a unidirectional flow of electromagnetic radiation, one can always choose co-ordinates in such a way that all but one component of the electromagnetic field tensor  $F_{\mu\nu}$  vanish. The simple solution which we wish to present here is couched in terms of such co-ordinates. The line-element is

$$ds^2 = -dy^2 - dz^2 + [1 + f(y, z, t) dt^2 + 2 dx dt] \quad (1)$$

All components of the contracted curvature tensor  $R_{ij}$  vanish save  $R_{44}$  and

$$R_{44} = -\frac{1}{2} \left( \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2} \right) \quad (2)$$

If we take  $dR_{44}/dz = 0$  we can associate an electromagnetic field with this line-element through the equation

$$R_{44} = -\frac{1}{2} g_{\mu\nu} R^{\mu\nu} = -8\pi [F_{\mu\nu} F^{\mu\nu} - \frac{1}{2} \delta_{\mu\nu} F^{\mu\alpha} F^{\alpha\nu}] \quad (3)$$

the only surviving component of  $F_{\mu\nu}$  being  $F_{24}$ . The line-element thus describes the gravitational situation in which there is a flow of electromagnetic radiation, the "wave-fronts" being the 3-surfaces  $t = \text{Constant}$  in the present co-ordinates.

We now switch off the electromagnetic radiation by setting  $F_{24} = 0$ . Then  $f(y, z, t)$  satisfies the Laplace's equation

$$\frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2} = 0 \quad (4)$$

giving  $R_{44} = 0$ . Thus  $R_{ik} = 0$ . One can choose  $f$  in such a way that the curvature tensor  $R^i_{klm} \neq 0$ . The line-element then takes a form similar to and yet distinct from that given by Rosen<sup>3</sup> for cylindrical gravitational waves. One can verify that O'Brien and Synge<sup>4</sup> jump conditions can be satisfied over a particular wave-front  $t = 0$  and yet  $R^2_{424}$ , for example, will be discontinuous over the wave-front. The solution thus represents gravitational waves in the sense of Pirani.<sup>1</sup> Since the line-element does not possess plane symmetry in the sense of Taub,<sup>5</sup> the waves are not (as is to be expected) plane waves, but are cylindrical waves originating from the infinite line  $y = 0, z = 0$ .

The above solution is a very simple particular case of a whole class of solutions of Einstein's field equations which give the same wave pattern for both gravitational and electromagnetic waves originating from similar sources. Detailed discussion of this class of solutions will be published elsewhere.

Gujarat University, P. C. VAIDYA,  
Dept. of Mathematics, I. M. PANDYA,  
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## EXCESS FREE ENERGIES FOR CONDENSED PHASES AT THE MAXIMUM AND MINIMUM MELTING-POINTS

A COMPARATIVE estimate of excess free energies of solid and liquid phases for suitable mixtures is necessary for getting an insight into the difference in the nature and magnitude of intermolecular forces for the solid and liquid phases. For regular mixtures the interchange energies for the two phases can be estimated from solid-liquid equilibrium data.<sup>1-3</sup> The estimation of excess free energies for non-ideal and non-regular mixtures is difficult if the vapour pressure measurements are tedious. However, the difference in excess free energies can be computed for binary mixtures which exhibit a maxima or minima in the freezing-point-compo-

sition of mixture melting entropies of pure components of the mixture phases<sup>4</sup>

The mixture phases<sup>4</sup>

- 1

where

$x_{ij}$

are respectively efficient components of heat capacity of liquid phase

The superscript phases. is usual maximum from eq

- 1

Since the and liquid

(G<sup>0</sup>)

and

(G<sup>0</sup>)

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(G<sup>0</sup>)

where (tions at ing the equation

$\Delta G^0$

Thus the divided the calculate Table I.

sition diagram. If the heat of fusion of the mixture having the maximum or minimum melting-point is known, the difference in excess entropies for the two phases can also be estimated provided the heats of fusion of the different components are known. The purpose of the present note is to demonstrate this.

The following relation holds for a binary mixture exhibiting miscibility in solid and liquid phases<sup>1</sup> at any temperature  $T$ :—

$$-\ln \frac{x_i^l r_i^l}{x_i^s r_i^s} = \frac{\Delta_i h_i^0}{R} \left( \frac{1}{T} - \frac{1}{T_i^0} \right) + \frac{\Delta_i C_{pi}^0}{R} \left( \ln \frac{T_i^0}{T} + 1 - \frac{T_i^0}{T} \right) \quad (i=1,2) \quad (1)$$

where

$$x_i, r_i, \Delta_i h_i^0 \text{ and } T_i^0$$

are respectively the mole-fraction, activity coefficient, heat of fusion, and melting-point of the component  $i$ ;  $\Delta_i C_{pi}^0$  is the difference in the heat capacities for component  $i$  in the solid and liquid phases; and  $R$  is the gas constant.

The subscript  $i$  refers to any component  $i$  and superscripts  $s$  and  $l$  refer to solid and liquid phases. The second term on the right-hand side is usually small and can be neglected. At the maximum or minimum temperature  $T_m$ , we have from equation (1)

$$-\ln \frac{r_i^l}{r_i^s} = \frac{\Delta_i h_i^0}{R} \left( \frac{1}{T_m} - \frac{1}{T_i^0} \right) \quad (i=1,2) \quad (2)$$

Since the excess free energies  $G^E$  in the solid and liquid phases are given by

$$(G^E)^l = RT (x_1^l \ln r_1^l + x_2^l \ln r_2^l)$$

and

$$(G^E)^s = RT (x_1^s \ln r_1^s + x_2^s \ln r_2^s) \quad (3)$$

and at the maxima or minima  $x_1^l = x_1^s$ , hence

$$(G^E)^l - (G^E)^s = -RT \left\{ (x_1^l)_m \ln \frac{r_1^l}{r_1^s} + (x_2^l)_m \ln \frac{r_2^l}{r_2^s} \right\} \quad (4)$$

where  $(x_1^l)_m$  and  $(x_2^l)_m$  are the mole-fractions at the maxima or the minima. Substituting the value of  $\ln r_1^l/r_1^s$  and  $\ln r_2^l/r_2^s$  from equation (2) in equation (4), we get

$$\Delta G^E = (G^E)^l - (G^E)^s = (x_1^l)_m \cdot \frac{\Delta_1 h_1^0 (T_m - T_1^0)}{T_1^0} + (x_2^l)_m \cdot \frac{\Delta_2 h_2^0 (T_m - T_2^0)}{T_2^0} \quad (5)$$

Thus the difference  $\Delta G^E$  can be computed provided the necessary data are available. This is calculated for a few mixtures and shown in Table I.

TABLE I  
Excess free energies of mixtures in the condensed phases

Mixtures	$\Delta_1 h_1^0$ (cal./mole)	$\Delta_2 h_2^0$ (cal./mole)	$(x_1)_m$	$T_m$ (°K)	$\Delta G^E$ (cal./mole)
<i>p</i> -Dibromobenzene- <i>p</i> -dichlorobenzene	4908 <sup>5</sup>	4340 <sup>5</sup>	0.0122 <sup>7</sup>	325.9	-8
<i>p</i> -Chlorobromobenzene- <i>p</i> -dichlorobenzene	4484 <sup>5</sup>	4340 <sup>5</sup>	0.0257	337.58	-5
<i>p</i> -Carvoxime- <i>l</i> -carvoxime	3857 <sup>6</sup>	3857 <sup>6</sup>	0.5 <sup>6</sup>	364.5	218

It would be interesting to have measurements of heat of mixing for the two phases for these mixtures in order to know how the excess entropy differs in the two phases. Even the determination of heat of fusion of mixtures would be good enough for this purpose. Unfortunately no such data are available except for *dl*-carvoxime. Hence, the difference in excess entropies could only be calculated for mixtures *d*- and *l*-carvoxime.

From elementary arguments we can show that Heat of fusion of *dl*-carvoxime

$$= H^l - H^s \\ = (x_1^l)_m \cdot \Delta_1 h_1^0 + (x_2^l)_m \cdot \Delta_2 h_2^0 + H_M^l - H_M^s.$$

Since

$$H^l = (x_1^l)_m H_1^l + (x_2^l)_m H_2^l + H_M^l$$

and

$$H^s = (x_1^s)_m H_1^s + (x_2^s)_m H_2^s + H_M^s,$$

where  $H_1$ ,  $H_2$  and  $H_M$  are the heat content of *dl*-, *d*- and *l*-carvoxime,  $H_M$  is the heat of mixing. The superscripts refer to the phases. Substituting the values of heats of fusion,<sup>6</sup>  $H_M^l - H_M^s$  is found to be equal to 204 cal./mole. Compared with the value of  $\Delta G^E$  for this mixture, it is found that the difference in the excess entropy in the two phases is very small, may be zero. A further point in this connection arises whether the excess entropy is zero for both the phases separately. This would imply that the mixture is regular for both the phases. This was tested by means of available solid-liquid equilibrium data<sup>6</sup> by the method developed earlier.<sup>2,3</sup> The mixture is neither symmetrical regular nor unsymmetrical regular. The temperature and concentration dependence of activity coefficients seems to be quite complex. Hence, it is concluded that the excess entropy in the two phases is not separately zero but their difference is very small or zero.

Incidentally, we can see from equation (2) that when liquid phase is more non-ideal than the solid phase we get maxima. The reverse is the case for minima. Since, mixtures with maximum melting-points are very rare, we can safely conclude that in general the solid phase is more non-ideal than the liquid phase.

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Chemistry Department, R. P. RASTOGI.  
Panjab University, R. K. NIGAM.  
Hoshiarpur, February 9, 1960. SARWAN SINGH.

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### INFLUENCE OF CATIONS ON THE AGGREGATING EFFECTS OF SYNTHETIC SOIL CONDITIONERS

In continuation of our previous studies<sup>1-4</sup> on synthetic polyelectrolytes as soil conditioners, the present investigation was undertaken to find out the influence of cation, viz.,  $\text{Ca}^{++}$ ,  $\text{Na}^+$ ,  $\text{H}^+$  on

the aggregating effects of synthetic soil conditioners on typical Indian soils.

Three synthetic polyelectrolytes—Krilium Loamaker (100% active) supplied by Monsanto Co., U.S.A., and a hydrolysed polyacrylonitrile (HPAN) and a copolymer of styrene and Maleic acid (SMA) prepared by us, were treated at the rate of 0.1% on dry basis with typical Indian soils, viz., Laterite (Ondal, West Bengal), Black Cotton soil (Nagpur) and Alluvial soil (Calcutta) saturated with  $\text{Ca}^{++}$ ,  $\text{H}^+$ , and  $\text{Na}^+$  ions. The procedure of treatment of polyelectrolytes with soil samples was the same as described in our previous communication.<sup>2</sup> In order to prepare  $\text{Ca}^{++}$ ,  $\text{H}^+$  and  $\text{Na}^+$  saturated soil samples, the soil samples were leached with 0.05 N.HCl and then washed with distilled water till no test for  $\text{Cl}^-$  was obtained in the leachate. These samples were further washed with alcohol and air-dried. The  $\text{H}^+$  saturated soil samples thus obtained were leached, for preparing  $\text{Ca}^{++}$  and  $\text{Na}^+$  saturated soil samples, with aqueous solutions of 0.5 N  $\text{CaCl}_2$  and 0.5 N  $\text{NaCl}$  respectively, then thoroughly washed with distilled water and air-dried. The size distribution of water-stable aggregates of soil samples was determined by a modification of Yoder's wet-sieving procedure.

Figures in Table II show that  $\text{Na}^+$  seems to exert favourable influence in comparison with  $\text{Ca}^{++}$  and  $\text{H}^+$ , in majority of cases, on soil aggregation as a consequence of treatment with synthetic and conditioners with Alluvial and

TABLE I  
Some characteristics of the soil samples

Properties	Alluvial Soil			Laterite Soil			Black Soil		
	$\text{H}^+$	$\text{Ca}^{++}$	$\text{Na}^+$	$\text{H}^+$	$\text{Ca}^{++}$	$\text{Na}^+$	$\text{H}^+$	$\text{Ca}^{++}$	$\text{Na}^+$
Hygroscopic moisture per cent ..	1.975	1.968	2.080	2.130	2.020	2.184	7.480	7.410	9.506
pH ..	5.42	7.68	9.15	4.52	6.05	7.29	4.45	7.54	8.96
Amount of different cations m.e/100 g.	11.88	13.05	10.17	12.80	6.40	5.75	33.73	48.40	37.61

TABLE II  
Influence of cations on the aggregating effects of synthetic polyelectrolytes  
Per cent. aggregates > 0.25 mm.

Polyelectrolytes	Alluvial Soil			aLaterite Soil			Black Soil		
	$\text{H}^+$	$\text{Ca}^{++}$	$\text{Na}^+$	$\text{H}^+$	$\text{Ca}^{++}$	$\text{Na}^+$	$\text{H}^+$	$\text{Ca}^{++}$	$\text{Na}^+$
Krilium ..	51.76	51.49	76.28	37.89	65.29	73.00	78.86	76.18	53.79
HPAN ..	58.03	56.49	74.58	62.54	81.80	77.12	61.06	76.15	48.26
SMA ..	56.30	39.60	76.76	69.17	85.19	82.49	77.43	72.87	33.33

Laterite soils. On the contrary  $\text{Na}^+$  reduces the effectiveness of synthetic polyelectrolytes in the case of Black Cotton soil.

Allison,<sup>5</sup> and Martin and Jones<sup>6</sup> reported increased aggregation in high sodium content soils on treatment with synthetic polyelectrolytes. On the other hand Martin and Aldrich<sup>7</sup> observed that binding action of some conditioner material was reduced by the presence of high ratios of exchangeable sodium and potassium. However, Tamhane<sup>8</sup> reported that Kriliun is not so effective in flocculating sodium soils but with the addition of gypsum, sodium is replaced by calcium and then it seems to be very effective. Mortensen<sup>9</sup> saturated clay minerals with various cations and reported the adsorption of HPAN in the following order  $\text{Ca}^{++} > \text{H}^+ > \text{Na}^+$ . The present results show that no generalisation regarding the influence of cations, viz.,  $\text{Ca}^{++}$ ,  $\text{Na}^+$ ,  $\text{H}^+$  on the aggregating effects of synthetic soil conditioners could be made. Evidently this influence seems to be governed by (1) Nature and amount of cations present in soils, (2) Nature of soils and (3) Nature of polyelectrolyte.

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Dept. of Physical Chem., TRILOKI NATH.  
Indian Association B. R. NAGAR.

for the Cultivation of Science,  
Jadavpur, Calcutta-32,  
April 23, 1960.

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### CAPSAICIN CONTENTS OF CHILLI VARIETIES

CHILLIES (*Capsicum annum*) are indispensable in Indian culinary and find extensive use due to their pungency in adding flavour to food. They are consumed in green, red as well as in sun-dried conditions. However, there is very little information regarding the quantitative

data on their content of capsaicin, the pungent principle. In the present preliminary note are reported the capsaicin contents of different varieties of green chillies available locally, and the change during ripening and sun-drying.

Capsaicin was extracted from the samples with acetone in a soxhlet extraction apparatus and was determined colorimetrically by the method of North,<sup>1</sup> using phosphotungstic-phosphomolybdic acid. However, instead of visual comparison of colour, as given in the original method, use was made of a Klett Summerson photoelectric colorimeter to read off the blue colour using a red filter (640 m $\mu$ ). For this purpose a graph was drawn using vanillin as the standard and the capsaicin contents were calculated from this graph. The results reported in Table I represent mgm. of capsaicin per 100 gm. of fresh material.

TABLE I

Sr. No.	Variety of chillies			Capsaicin mg./100 g.
1	"Phugi"	(big)	green	7.5
2	Dharwar	(big)	green	23.7
3	"Lavangi"	(small)	green	29.4
4	Local	(small)	green	17.6 (167.6)
	Local	(small)	ripe	57.0 (120.0)
	Local	(small)	sun-dried	80.0 (92.1)

(Figures in brackets represent the results on moisture-free basis.)

The data show that the small "Lavangi" variety, well known for its pungency, contains the highest concentration of capsaicin, while the big "Phugi" variety, used as a vegetable, contains the least. Further, capsaicin content, expressed on moisture-free basis, decreases during ripening and sun-drying of chillies.

Chem. Res. Lab., T. S. ANANTHA SAMY.  
College of Agric., V. N. KAMAT.  
Poona-5, H. G. PANDYA.  
April 25, 1960.

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### MINOR CONSTITUENTS OF SEA-WATER

DATA on the minor constituents in sea-water are of interest from the viewpoint of chemical oceanography. Published work shows that the concentration of minor constituents vary to a much greater extent than those of the major constituents from region to region depending upon seasons and the wealth of the organic populations near the coast.



TABLE I

Constituents	Bhavnagar Sea-water	Known values	Reference
(Micrograms per litre)			
Strontium	11,800	9,000-11,000	Smales (1951) <sup>1</sup>
		8,150	Odum (1951) <sup>2</sup>
Boron	2,200	1,530-5,100	Igelsrud <i>et al.</i> (1938) <sup>2</sup>
Fluorine	800	1,400	Thompson and Taylor (1933) <sup>3</sup>
Silicon	515	10-1,000	Armstrong (1951) <sup>3</sup>
		(depending on depth)	
Rubidium	640	200	Goldschmidt (1937) <sup>3</sup>
Lithium	160	100	Thomas and Thompson (1933) <sup>3</sup>
Aluminium	26.8	27-270	Armstrong <sup>3</sup>
		100-1,800	Haendler and Thompson (1939) <sup>4</sup>
Iron	160	15-50	Thompson and Bremner (1935) <sup>3</sup>
Copper	30.0	1-25	Chow and Thompson (1952) <sup>5</sup>

Analyses of Indian coastal waters for the minor constituents do not appear to have been attempted so far. Sea-water, collected during high tides in March-April 1959 at Bhavnagar, was analysed by us for some of its minor constituents. The data obtained are compared in Table I with similar data reported in the literature for other ocean-waters.

Analytical methods adopted and other details will be published later.

A. N. KAPPANNA.

Central Salt Res. Inst.,

G. T. GADRE.

Bhavnagar,

H. M. BHAVNAGARY.

June 30, 1960.

J. M. JOSHI.

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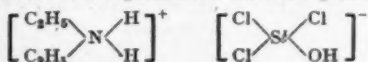
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### A COMPLEX OF BISMUTH

#### TRICHLORIDE WITH DIETHYLAMINE

SECONDARY amines have very little tendency to function as donor molecules. Mohapatra and Nanda<sup>1</sup> attempted to study the reaction of an aliphatic secondary amine (diethylamine) with a saturated aqueous solution of antimony trichloride and represented the final product as



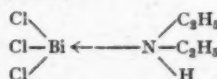
which obviously appears to be quite similar to the type obtained with dioxane.<sup>2</sup> This work has been extended to study how bismuth trichloride, in an acetone solution, reacts with diethylamine.

To a concentrated solution of bismuth trichloride in dry acetone purified diethylamine

was added dropwise from a burette with constant stirring. HCl gas was given off and a solid product settled down. It was filtered, washed with dry acetone and kept in a vacuum desiccator over sulphuric acid for about a week. To determine its composition a known weight of the solid was dissolved in minimum quantity of dilute hydrochloric acid and bismuth was estimated as oxychloride.<sup>3</sup> The value (mean) as calculated from three separate experiments was found to be 58.52%. Further analysis of the solid gave C = 12.83%, N = 4.00% and Cl = 21.78%. These values agree with the formula,  $\text{BiCl}_2\text{N}(\text{C}_2\text{H}_5)_2$  which requires, Bi = 59.37%, C = 13.63%, N = 3.98% and Cl = 20.17%.

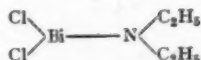
The compound does not show any solubility in water, alcohol, ether, carbon tetrachloride and benzoyl chloride but dissolves readily in mineral acids with the liberation of  $\text{Bi}^{3+}$  ions. It is also decomposed by heat and begins to fuse with decomposition at 204°C. when it turns black. It is not hygroscopic in nature.

Diethylamine is a base whereas bismuth trichloride behaves as an acid in numerous chemical reactions. A close study of all these facts indicates that the amine must be attached to the central atom (Bi). In fact, nitrogen, due to its donor character, lends its lone pair of electrons to bismuth with the formation of a co-ordinate compound,



at the first instance. But this is not a stable arrangement as is obvious from the formation of HCl gas during the interaction of the reactants and the system undergoes a further internal rearrangement to yield,





as the final product. The solubility of the final product in dilute hydrochloric acid with the liberation of free  $\text{Bi}^{3+}$  ions evidently shows that both, bismuth trichloride and diethylamine, are set free in this solution once again.

But the fact that it does not dissolve in non-polar solvents does not furnish an evidence in support of its being a covalent compound.

Dept. of Chemistry, KUNDAN LAL.  
Panjab University,INDER PAL BHATIA.  
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April 14, 1960.

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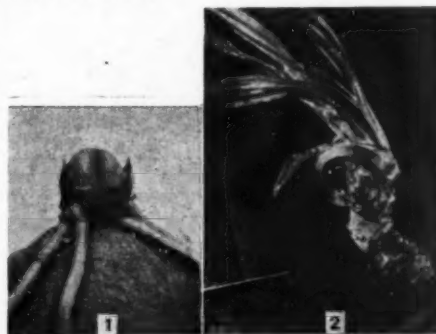
#### CLONAL PROPAGATION IN COCONUTS

HOLTUM,<sup>1</sup> Harland<sup>2</sup> and Haldane<sup>3</sup> have pointed out that, if coconut palms or other economically valuable palms can be propagated vegetatively, on the one hand high yielding trees can be multiplied indefinitely, and on the other hand the expenses of manurial trials can be greatly reduced, since trees derived from the same original by cuttings are likely to resemble one another very closely in the same environment. Vegetative propagation could be through cuttings, suckers or vegetative buds, or by grafting on to other seedlings.

Though the coconut is normally a single-stemmed tree, suckering is observed,<sup>4</sup> though rarely. This is perhaps an atavistic character, since it is normal in many less specialised palm species. I succeeded in separating eight suckers from one and four from another suckering coconut palm at the Central Coconut Research Station, Kayangulam, Kerala, and thus establishing clonal propagation. I also recently proved the feasibility of air layering the branches of branching coconut palms, which are very rare, separating the branches, and raising them as independent "seedlings" after inducing numerous roots in them.

Although conditions for the production of suckers and branches in coconut trees occur in nature, no deliberate attempt has yet been made to induce their formation artificially. In preliminary attempts on a small number of coconut sprouts and seedlings at Kayangulam, I have been able, by dividing a growing point, to induce the production of two suckers from a sprout.

This interesting seedling is being maintained at Kayangulam. In Figs. 1 and 2, two coconut sprouts on their way to develop suckers can be seen. Details and further results will be published elsewhere.



FIGS. 1-2

I am grateful to Dr. K. P. V. Menon, Director, Central Coconut Research Station, Kayangulam, for the encouragement received for starting this line of investigation.

Biometry Research Unit,  
Indian Statistical Institute,  
Calcutta-35, May 26, 1960.

T. A. DAVIS.\*

\* Formerly at the Central Coconut Research Station, Kayangulam, Kerala.

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#### ACERENTULUS BREVIUNGUIS CONDE (PROTURA: ACERENTOMIDAE) FROM INDIA

Very little is known about the Protura of the Indian region. Schepotieff<sup>1</sup> described *Protapteron indicum* from Mahe as a Proturan with many-segmented antennae and without pseudoculi. Rimsky-Korsakow<sup>2</sup> re-examined the type of *Protapteron indicum* and showed it to be a species of *Eosentomon* stating that the description of Schepotieff was not correct. The only other record of Protura from the Indian region is that of Conde<sup>3</sup> where he describes two new species from Nepal, viz., *Eosentomon hyatti* and *Proturentomon regale*.

During the course of a survey of the soil microfauna of the tea-growing areas of Kerala, a few specimens of Protura were obtained from Sentinel Rock Estate at Wayanad in the State. They were collected from a height of about

2,500 ft. above sea-level, from damp, loamy soil 2 to 3 inches deep and rich in humus content. The specimens were found to be *Acerentulus breviunguis* Conde, a species that is being described from Madagascar by Conde.<sup>4</sup>

The Indian form, however, shows a few differences from the type specimens. The pseudoculi are rounded and divided and not elliptical; the peg-like sensory seta  $t_1$  at the tergal aspect of Tarsus I (Fig. 1) is in front of the tergal seta 4 instead of behind it, in which case it resembles

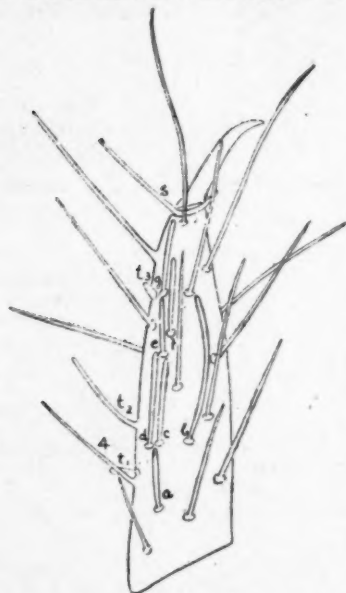


FIG. 1. Posterior face of Tarsus I of *Acerentulus breviunguis* Conde

a, b, c, d, e, f, g: lateral sensillae;  $t_1$ ,  $t_2$ ,  $t_3$ : tergal sensillae; s: pretarsal sensilla; 4: tergal seta. Magnification,  $\times 750$ .

*Acerentulus gracilis* Berlese; the lateral sensilla c of Tarsus I arises almost at the level of the sensilla d rather than behind it; the claw is about one-third the length of Tarsus I; the chaetotaxy shows the presence of 2 additional inner setae on each side of the pronotum making a total of 8 instead of 4; mesonotum shows 13 setae instead of 22; metanotum with 14 setae instead of 20 and tergite VII of abdomen with 6 setae and 16 setae respectively in the anterior and posterior rows, instead of 4 and 14 respectively.

Some of the salient features of *Acerentulus breviunguis* Conde in the present collection are the comparatively large size with a total length

averaging about 986  $\mu$ ; the presence of 2 sensillae in the anterior face of Tarsus I; the nature of the lateral sensilla b in the posterior face of Tarsus I which is the largest; and the 'filament de soutien' of the maxillary gland with a distinct apical swelling and an opening at the tergal end.

This is the first record of the family Acerentomidae and the genus *Acerentulus* from India and it is interesting that a species newly recorded from Madagascar is represented in India also.

The author is grateful to Dr. B. Conde, Nancy, for the identification and an advance copy of the description of the species from his memoir under publication; to Dr. K. K. Nayar, Professor of Zoology, for guidance; and to the Indian Tea Board for funds provided.

Tea Board Research Scheme

on Soil Microfauna,

N. R. PRABHOO.

Dept. of Zoology,

Government College,

Chittur-Cochin, February 29, 1960.

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#### ON THE SECRETORY ACTIVITY OF THE FUNNEL OF THE AVIAN OVIDUCT

THE avian oviduct in the active state shows five well-defined regions,<sup>1,3-5,7</sup> viz., the funnel or infundibulum, the magnum or albumen secreting region, the isthmus or shell membrane secreting region, the uterus or shell gland and the vagina, which does not contribute anything materially to the formation of the egg.<sup>1,3-5,7</sup> Opinions are divided in regard to the secretory role of the funnel.

A detailed study of the oviducal cycle of the domestic pigeon, *Columba livia*, by the present author,<sup>3</sup> shows that the funnel in an active oviduct bears narrow longitudinal folds which are lined uniformly by a ciliated epithelium in which no glandular cells are discernible, except in the shallow pits between adjacent folds where non-ciliated cells of a glandular character exist. These areas are usually termed 'glandular grooves'.<sup>2,7</sup> Controversy still rages round the 'glandular grooves' as being a possible source of secretion. Surface<sup>7</sup> and Bradley<sup>2</sup> did not find any secretion in these grooves, while Bela<sup>1</sup> totally denied the presence of gland cells in the funnel. Richardson<sup>5</sup> also made an identical

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observation and reported that the cells in the 'glandular grooves' remained "curiously constant", while Giersberg<sup>4</sup> noticed, in the glandular grooves, the presence of a faintly staining homogeneous secretion unlike albumen.

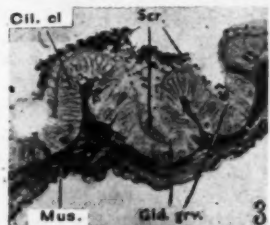
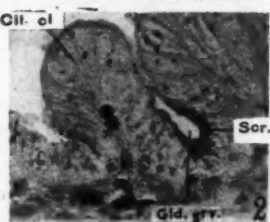
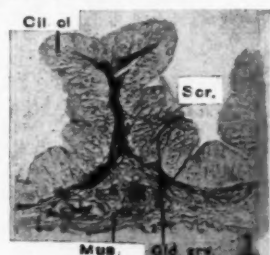
The present author has studied the oviducal funnel of *C. livia* in various phases of activity. When the funnel is ready to receive the egg (Figs. 1 and 2), the cells in the 'glandular grooves' secrete a homogeneous fluid which in the initial stages stains only faintly. This secretion is seen in and around the 'glandular grooves'. Later, when the egg enters the funnel (Fig. 3), the cells in the 'glandular grooves' show

over the epithelial surface and also in the lumen of the funnel. This secretory matter resembles albumen by its staining reactions and is almost indistinguishable from the albumen that is secreted by the tubular glands of the magnum.

To the best of my knowledge, this kind of secretory activity in the funnel of the avian oviduct has not been reported before.<sup>1,2,4-7</sup> The results recorded here in the case of the domestic pigeon show that, apart from grasping the released ovum, the funnel also produces a kind of secretion. This is in agreement with the suggestion of some investigators<sup>3,5-7</sup> who hold that the funnel of the avian oviduct secretes a portion of the white of the egg.

I am indebted to Prof. A. B. Misra of the Banaras Hindu University, for his kind supervision of this work.

Department of Zoology, C. J. DOMINIC.  
Banaras Hindu University,  
Varanasi-5, March 21, 1960.



FIGS. 1-3. Fig. 1. A portion of the funnel showing the 'glandular grooves' in the initial stage of secretion,  $\times 280$ . Fig. 2. A portion of the funnel showing the 'glandular grooves' with secretion in it,  $\times 527$ . Fig. 3. A portion of the funnel showing the 'glandular grooves' in the active phase of secretion, secretory globules being attached to the surface of the epithelial cells,  $\times 293$ .

Cil. cl., Ciliated cells; Gld. grv., Glandular groove; Mus., Muscle layer; Scr.: Secretion.

maximum of secretory activity. The secretion which is at first homogeneous and faintly staining turns into dark brown globules later. These secretory globules are seen to be scattered all

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# ON SOME CRUSTACEAN WOOD-BORERS FROM ANDAMANS

CRUSTACEAN wood-borers belonging to the Isopod families Limnoriidae and Sphaeromidae are well known for their depredations on submerged wooden structures in the sea such as jetty pilings. Menzies<sup>1</sup> has made a comprehensive survey of the systematics, ecology and world distribution of 15 species of wood-boring Limnoriidae reported till the year 1956, of which only two are from Indian waters. In addition, he has reported 7 other species, which are algal borers. Since the publication of Menzies' monograph two more species of wood-borers<sup>6,7</sup> and one species of an algal borer<sup>5</sup> have been discovered.

Recently we had the opportunity of examining a submerged wooden plank collected from the Chatham Islands Timber-Yard in Andamans, which was completely riddled by Limnoria together with a few teredinids. The present note is a preliminary report on the Limnoriids from the infested wood.

Five species of *Limnoria* have so far been reported from Indian waters<sup>2-5,7</sup> of which three are from the Indian coast, one from Minikoi

Island and only one from the Andamans Sea. We have been able to identify as many as five species from the infested wood of which only *Limnoria* (*Limnoria*) *indica* Kampf. and Becker has been previously reported from the Indian Coast. Three of the species *L. (L.) insulæ* Menzies, *L. (L.) unicornis* Menzies and *L. (L.) platycauda* Menzies have not been previously recorded from Indian waters. All the five are new records from the Andamans. The only species of *Limnoria*, namely, *L. (L.) septima* Barnard<sup>3</sup> previously reported from Andamans was not present in our collection. We are giving

We are thankful to Sri. D. V. Subba Rao for collecting the infested log of wood and to the authorities of I.N.S., CIRCARS, Visakhapatnam, for kindly arranging his visit to Andamans in connection with the Naval Expedition "SURVIVAL" in January, 1960.

This work has been carried out with the funds provided by the Forest Research Institute, Dehra Dun, obtained from various sources for the execution of the Scheme on "Protection of Timber against Marine Organisms' Attack".  
Dept. of Zoology, P. N. GANAPATI.  
Andhra University, M. V. LAKSHMANA RAO.  
Waltair, April 29, 1960.

TABLE I

Name of species and author	Type locality	Distribution	Ocean
<i>L. (L.) pfefferi</i> Stebbing	Minikoi Atoll	Minikoi Island and Miami, Florida. Andamans (Present record)	Indian and West Atlantic
<i>L. (L.) insulæ</i> Menzies	Serua, Fiji Isl.	Fiji, Guam, Palmyra and Caroline Isles. Andamans (Present record)	South Pacific and Indian
<i>L. (L.) unicornis</i> Menzies	Ponape, Caroline Isl.	Ponape, Caroline Isles. Andamans (Present record)	do.
<i>L. (L.) platycauda</i> Menzies	Curacao Harbour, Dutch West Indies	Caribbean Puerto Rico to Curacao, Dutch West Indies. Andamans (Present record)	West Atlantic (Caribbean) and Indian
<i>L. (L.) indica</i> Kampf and Becker	Mandapam and Madras Harbour	Mandapam and Madras Harbour Andamans (Present record)	Indian

below a statement (Table I) of the five species identified and their world distribution.

The present report raises the number of identified wood-boring Limnoriids in Indian waters from 4 to 7 and also indicates the extended distribution of *L. (L.) insulæ*, *L. (L.) unicornis* and *L. (L.) platycauda* to the Indian waters. It may also be pointed out that most of these borers in Indian waters have been discovered only in very recent years, since the inauguration in 1953, of a scheme on marine wood-boring organisms, at a few centres along the east and west coasts of India, by the Forest Research Institute, Dehra Dun. It therefore seems likely that many more of these borers may be discovered with an extension of the area of investigation.

Apart from the academic interest attached to the extended distribution of some of the Limnoriids into the Indian waters the present study may also have some practical significance in that large quantities of timber are at present imported from Andamans to India and there is always the potential danger of these borers establishing themselves in Indian Coastal Harbours.

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#### A PRELIMINARY NOTE ON THE ISOLATION OF MORAXELLA CAPRAE NOV. SP. FROM AN OUTBREAK OF INFECTIOUS KERATOCONJUNCTIVITIS IN GOATS

DURING routine bacteriological examination of materials collected from six sick goats suffering from a disease syndrome varying from an acute panophthalmitis to chronic keratitis and opacity of cornea, a gram-negative, non-motile, coccobacillary organism was isolated in pure culture in all the instances from the ocular discharges. Its predominant occurrence in pairs, possession of a microscopically demonstrable capsule,

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positive reactivity towards the oxidase test, extreme sensitivity to penicillin (Henriksen, 1952)<sup>1</sup> and proteolytic activity demanded its allocation to the genus *Moraxella*, which at present accommodates the following three species—*M. lacunata*, *M. liquefaciens* and *M. bovis* (Murray in Breet et al., 1957).<sup>2</sup> Its capacity to liquefy gelatin or coagulated serum quickly placed the new isolates taxonomically apart from the two species *M. lacunata* and *M. bovis* and nearer to *M. liquefaciens*. However, the properties of haemolysis on horse/sheep/goat/rabbit/guinea pig (but not ox or fowl) blood agar plates, elaboration of soluble oxygen-labile haemolysins in Todd Hewitt broth cultures, lack of fermentative ability and pathogenicity to mice exhibited by these caprine strains seriously questioned the validity of its systematic identity with the species *M. lacunata*. The above observations have since been confirmed by Prof. E. G. D. Murray, University of Western Ontario, Canada.

These characters seemed to be significant enough to justify creation of a new species in the genus *Moraxella* and to this, the name *M. caprae* nov. sp. is provisionally proposed. The problem of speciation in this genus deserves a more critical study (Henriksen, 1952; 1960)<sup>1,3</sup> and it is realised that it should be based on the more stable antigenic characteristics. Studies by agglutination and agglutinin-absorption techniques as well as by specific capsular reaction showed that the new isolates were antigenically distinct from the three above-mentioned species. To confirm these findings and solve this taxonomic riddle, comparative immunochemical and serum-agar double diffusion studies are in progress, the results of which will be published in due course of time.

From the aetiological standpoint, it may be pertinent to state here that, based on its occurrence in predominant numbers in smears and cultures of ocular exudates, presence of homologous agglutinins to a high titre (1:64 to 1:128) in the discharges from the eyes of affected but not normal goats, its ocular pathogenicity to mice, rabbits and goats under experimental conditions coupled with the well-known ophthalmic pathogenic status of the other three species to man and cattle, *M. caprae* may well have a direct or an indirect association with this disease. Whether it is the sole pathogen or is only an ancillary factor inducing synergistic infections with viruses or rickettsiae remains to be determined. Further aetiological and epizootiological investigations designed to throw light on many of these aspects are being

carried out and it is hoped to present these data in a separate paper elsewhere.

Leptosira Laboratory, P. G. PANDE.  
Indian Vet. Res. Inst., P. C. SEKARIAH.  
Mukteswar, Kumaon, U.P.,  
March 30, 1960.

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### ON THE PRODUCTION OF UNDERWATER SOUND BY *THERAPON JARBUA*

THOUGH subsurface production of sound by fish has been demonstrated in 27 North Atlantic coastal species by Fish et al. (1952), and Fish (1954), such sound production by fishes has not yet been reported from this country. These underwater sounds escape common notice since they are scarcely audible above the surface of water, and special acoustical instruments are necessary to detect them underwater. Such "biological sounds" appear to be purposeful and originate within the body of the fish itself. These are distinguished from "mechanical noises" produced by swimming, feeding, collision, and other activities of fish. A number of marine mammals (Fish, 1949; Kellog et al., 1953; Griffin, 1955), and a few crustaceans (Johnson et al., 1947) have been shown to produce such sounds, which contribute largely to the underwater ambient noise.

Although the squeaking perch (*Therapon jarbua*) is known to fishermen as "Keechan" (Tamil—meaning a sound producer), the lack of a systematic study with the help of precise electro-acoustical instruments has been mainly responsible for our general ignorance regarding underwater sound producers like this species.

If the fish is lifted out of water and thus irritated it makes a slight snappy movement of the head region producing a series of short bursts of sound lasting about one or two seconds. Careful examination of the oesophageal "mill" as well as dissection and Alizarin preparation reveal that the sound-producing organs are special modifications of the "mill". They consist of two prominent dorsal rounded muscular pads placed close together on the roof of the pharynx (see Fig. 1). These muscular pads do not have any skeletal support but they rest against the bony base of the skull. On the outside the pads

bear numerous recurved teeth of dermal origin. On the ventral floor of the pharynx there is a triangular pad supported by two bony vestiges of the fifth branchial arch meeting to form a forward directed apex. This triangular pad can be raised through the contraction of the pharyngeal muscles and pressed against the recurved teeth of the dorsal pads (see Fig. 1B). It is probable that movements akin to those performed during swallowing will result in the to and fro

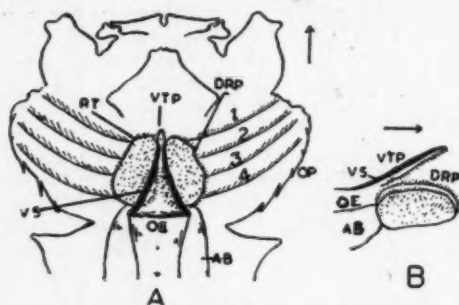


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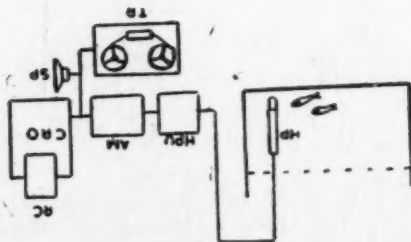


FIG. 2

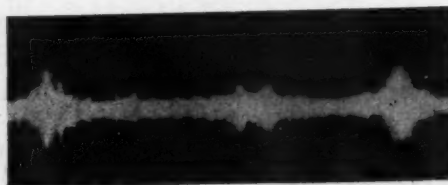


FIG. 3

FIGS. 1-3. Fig. 1. (a) Dissection from the ventral side of pharynx of *Therapon jarbua* to show the sound-producing organs. (b) Lateral view of the sound-producing organs. AB—Air-bladder; DRP—Dorsal round pads; OE—Oesophagus; OP—Operculum; RT—Recurved teeth; VTP—Ventral triangular pad; 1, 2, 3, 4—Branchial arches; VS—Vestige of fifth branchial arch. Fig. 2. Arrangement of apparatus used for recording underwater sounds produced by fishes. AM—Amplifier; CRO—Cathode-ray oscilloscope; HPU—Hydrophone; HP—Hydrophone power unit; SP—Speaker; TR—Tape recorder. Fig. 3. Oscillographic pattern of short bursts of underwater sounds produced by *Therapon jarbua*. (Film—Kodak Photofleare, Speed—9.5 cm./sec.)

rubbing of the triangular pad against the recurved teeth. The sounds which thus originate through friction are amplified by the air-bladder which though closed can act as a resonator since its anterior end is placed against the dorsal pads of the "mill" referred to above.

It is significant that these fishes not only produce the sounds when handled in air but also produce similar sounds spontaneously when left free in the aquarium. This fact can be actually proved by recording these sounds experimentally through a hydrophone (M 115 B) lowered into the aquarium in which the fishes were left free (see Fig. 2). Such sounds made by fish spontaneously without any apparent stimulation were amplified and recorded on magnetic tape for spectral analysis and further experiments. Later the sounds so recorded were played through a cathode-ray oscilloscope and the wave patterns of the sounds were photographed from the oscilloscope screen (see Fig. 3). Further, the intensity of the sounds was measured through a calibrated system of amplifier and output meter. It was found that the sounds had an intensity of about 20 to 30 db. above a reference level of 0.0002 dynes/sq. cm.

The exact biological significance of the underwater sounds produced by perches is rather difficult to determine at this stage. It is probable that such voluntary production of sound may be associated with shoaling behaviour and with group migrations. Further studies on this, and details of the mechanics of the production and resonance of these sounds are being made and will be reported later.

I wish to thank Prof. C. P. Gnanamuthu, Director of this Laboratory, for outlining the work and for his unfailing guidance throughout this work. My thanks are also due to Dr. S. Krishnaswamy, Reader in this Department, for his useful discussions.

Zoological Research Lab.,  
University of Madras,  
Madras, May 16, 1960.

B. S. DORAI RAJ.

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## CHROMOSOME NUMBERS IN VITACEÆ

CHROMOSOME numbers for seven cultivated varieties of grapes and sixteen wild species spread over five genera of Vitaceæ were reported in a previous paper (Shetty, 1958). In the present note chromosome counts for nine more varieties of *Vitis vinifera* and seven wild species belonging to four genera of the family are recorded in Table I.

TABLE I

Species and variety	Chromosome number		Source		
	2n	n	Place	District	State
1 <i>Vitis vinifera</i> L.					
(i) Pandhari Sahebi	.. 38	..	Ganeshkhind Fruit Experiment Station	Poona	Bombay
(ii) Kali Sahebi	.. 38	..	"	"	"
(iii) Gulabi	.. 38	..	"	"	"
(iv) Bhokari	.. 38	..	"	"	"
(v) Karachi	.. 38	..	"	"	"
(vi) Kandhari	.. 38	..	"	"	"
(vii) Muscat	.. 38	..	"	"	"
(viii) Selection No. 7	.. 38	..	"	"	"
(ix) Selection No. 94	.. 38	..	"	"	"
2 <i>Ampelocissus araneosa</i> (Laws.) Planch...	80	..	Yercaud	Salem	Madras
3 <i>Tetrastigma muricatum</i> Gamble	.. 44	..	Courtallam	Tinnevely	"
4 <i>Cissus repanda</i> Vahl.	.. 24	..	Top Slip (Anamalais)	Coimbatore	"
5 <i>Leea macrophylla</i> Roxb.	.. 24	12	Walayar	"	"
6 <i>L. indica</i> (Burm.) Merr. (= <i>L. sambucina</i> Willd.)	.. 24	12	Top Slip	"	"
7 <i>L. robusta</i> Roxb.	.. 24	12			
8 <i>L. edgeworthii</i> Santapau (= <i>L. aspera</i> Edg. non Wall.) *	.. 48	..		Gauhati	Assam

Krishnaswamy *et al.* (1954) reported the diploid chromosome number for *Cissus pallida* as 26. Further work revealed that the correct number for this species is 24 (Shetty, 1958, 1959). Darlington and Wylie (1955) regard *C. repanda* as a synonym of *C. pallida*. These species were collected by the authors and established at the Agricultural College orchard, Coimbatore. They were analysed and carefully compared with the specimens at the Regional Herbarium, Botanical Survey of India, Coimbatore, and identified as *C. pallida* (W. & A.) Planch. and *C. repanda* Vahl. respectively. The two species are distinct taxonomically thus supporting Planchon (1887) who has proposed the best classification for this family (refer and Raizada, 1958).

The diploid chromosome number recorded for *Ampelocissus araneosa*,  $2n = 80$  is the highest record for this genus. The earlier counts (Shetty, 1958, 1959) for two other species of this genus, viz., *A. latifolia* and *A. tomentosa* were  $2n = 40$ .

The somatic number in *Tetrastigma muricatum* like that of *T. lanceolarium* is 44 and this

number is twice that of *T. sulcatum* which is 22 (Shetty, 1958, 1959). This is the second record of a tetraploid species in the genus *Tetrastigma*.

Chromosome number reported for four species of *Leea* is the first record for the genus. Polyploidy is evident in this genus, *L. edgeworthii* having the somatic number 48, while the diploid number in the three other species, *L. macro-*

*phylla*, *L. indica* and *L. robusta* is 24. It may thus be pointed out that polyploidy has played a significant role in speciation of Vitaceæ as discussed already (Shetty, 1959).

The somatic chromosomes of all the sixteen varieties of cultivated grapes so far investigated, appear identical in size and morphology.

The authors are grateful to Sri. P. C. Das, Divisional Forest Officer, Jhum Control Division, Gauhati, Assam, for supply of *L. edgeworthii* and the Horticulturist, Ganeshkhind Fruit Experiment Station, Poona, for supply of the cultivated varieties of grapes. The observations reported here form part of the investigations financed jointly by the Government of Madras and the Indian Council of Agricultural Research.

Cytogenetics Lab.,  
Agric. Res. Institute,  
Coimbatore-3,  
December 28, 1959.

B. V. SHETTY.\*  
V. S. RAMAN.

\* Present Address: Botanical Survey of India, Southern Circle, Coimbatore-2.

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**RESISTANCE OF BARLEY VARIETIES AGAINST LOOSE SMUT [*USTILAGO NUDA* (JENS.) ROSTR.] AND COVERED SMUT [*USTILAGO HORDEI* (PERS.) KELLERM. AND SWINGLE] IN UTTAR PRADESH**

BARLEY (*Hordeum vulgare* L.), an important cereal of Uttar Pradesh suffers from several fungus diseases, of which the smuts are the most important. Appreciable damage is estimated to be caused by loose smut and covered smut.

**A. LOOSE SMUT**

The disease can be easily recognised in barley fields because diseased ears appear earlier and instead of having grains, are filled with black powdery mass of spores. The fungus is internally seed-borne, hence it is not easily killed by the application of common fungicides in doses not injurious to the viability of the seed. Hence amongst effective means of controlling the disease, the use of resistant varieties is the most important.

With a view to evolve barley varieties resistant to loose smut, a large collection of barley was obtained from the Economic Botanist (Rabi Cereals and Potatoes) to Government, Uttar Pradesh, Kanpur, and tested under field conditions during the period 1953-59. Seeds of different varieties were collected from the plants inoculated previously with a heavy suspension of freshly collected viable spores of *Ustilago nuda* by Moore's partial vacuum method<sup>1</sup> when they were in the flowering stage. In order to prevent quick evaporation of the spore suspension, inoculations were invariably carried out in late afternoons. The inoculated seed was sown in 18 ft. (rod row), single line, 2 ft. apart, randomised and replicated four times. Normal agricultural practices like weeding, hoeing and irrigation were followed.

Loose smut ears appeared earlier than the normal ones, and were counted at regular intervals. Finally the normal ears were also counted and a percentage of infected ears was calculated.

The barley varieties arranged according to infection rating, average of six seasons (1953-59) are given in Table I.

**TABLE I**

Grade of resistance	Varieties
1 Resistance (Below 1%)	Nil
2 Fairly tolerant (1-5%)	C 44, CN 292, CN 294, Black barley, NP 13, C 50
3 Moderately susceptible (5-10%)	K 7, C 84, 42/69, Ramni, Bolivia, Peatland, K 1, K 2, K 8, K 12, C 86, C 251, Ballia, 42/72, JBS 30, IW 112/B 2, IW 112/B 6, IW 112/B 7
4 Susceptible (10-15%)	NP 21, JBS 8, C 250, K 15, K 3, K 14, JBS 29, JBS 21, IW 112/B 1
5 Highly susceptible (Above 15%)	IW 112/B 5, Flynn

**B. COVERED SMUT**

The other damaging disease of this crop is the covered smut. Year after year covered smut has caused losses from 2.5 to 30% of the crop because the cultivator does not often obtain seeds from healthy crop and fails to treat the seed with a mercurial fungicide, e.g., Agrosan G.N. or Ceresan before sowing. Fungicidal seed dressings have proved effective in controlling the disease if the initial infection is not more than 5%.

The alternative to seed dressing is to grow resistant varieties and research work on the problem has been in progress in this laboratory for over ten years. Some results of this work have already been published.<sup>2</sup>

In the present note, results are given of testing barley varieties during the period 1956-59 for their resistance against covered smut.

During the course of investigation, seeds were artificially inoculated by soaking them in smut spore suspension (2 gm. of spores per 100 c.c. of water), vigorously agitating the mixture for 15 minutes and then subjecting the same to partial vacuum.<sup>3,4</sup> Inoculated seeds of different varieties were sown in two rows of 10 ft. each, replicated four times. Data of smut infection was taken by counting smutted and healthy heads. On the basis of data obtained during the period 1956-59, the maximum infection percentage of the varieties have been rated as Table II, according to their susceptibility to covered smut.

**Grade**

1. Moderate
2. Moderate
3. Susceptible

Thank  
(Rabi Cereals)  
Uttar Pradesh  
barley varieties  
Laboratory  
Pathology  
U.P., Kanpur  
February 1959

1. Moderate
2. Moderate
3. Moderate
4. Moderate

**A. NO.**

FLOWERING  
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TABLE II

Grade of resistance	Varieties
1 Moderately resistant (below 2%)	C 50, K 18, CN 292, C 84, K 19, <i>Basipur local</i>
2 Moderately susceptible (below 10%)	NP 21, K 12, C 251, CN 294, K 16
3 Susceptible (above 10%)	KN 15, KN 17

Thanks are due to the Economic Botanist (Rabi Cereals and Potatoes) to Government, Uttar Pradesh, Kanpur, for supplying seed of barley varieties for trials.

Laboratory of the Plant Pathologist to Govt., U.P., Kanpur,  
February 23, 1960.

R. S. MATHUR.  
S. C. MATHUR.  
K. N. SAKSENA.  
S. C. VERMA.

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#### A NOTE ON COLCHICINE-TREATED PHLOX

FLOWERS of many of the induced tetraploid flowering annuals were found to be much showy and bigger in size. Besides the tetraploids are robust in form though they have a slower rate of growth than the diploids. Tetraploidy has earlier been reported<sup>1</sup> in *Phlox drummondii* by treatment with colchicine. An attempt was, therefore, made to study the effect of Colchicine on phlox seed at Government Agricultural College, Kanpur.

Phlox seed was treated with different concentrations of Colchicine (0.1%, 0.05%, 0.025% and 0.0125%) for three, six, twelve and twenty-four hours.

The immediate effect of the Colchicine treatment was reduction in the germination percentage. At higher concentrations and longer durations of treatment the germination was greatly retarded. The germination percentage with respect to the treatment with 0.1% aqueous solution of Colchicine for 12 and 24 hours was 50 and 40 respectively as against 95 and 100% in control.

The rate of shoot growth of the polyploid plant was slower than the control. However, in the long run they were taller and were of

bushy appearance owing to larger number of branches than the control (Table I). The leaves of the treated plants were thicker, coarser and broader in size and had larger stomata size and fewer number of stomata per microscopic field as compared to that of control. The average size of the pollen grains of the polyploid plants was  $44\mu$  against  $36\mu$  of the control. The pollen sterility in the polyploid plants was 25.4% against 10% in the control.

TABLE I

Showing mean height of plants as influenced by different Colchicine treatment

Treatment	Mean height in cm.	Difference between means	S.Ed.	't' calculated	Table value of 't' at 5%	Remarks
Control ..	11					
Treated ..	18.7	6.7	0.57	11.7	2.101	Significant

Nevertheless, the most outstanding feature which attracts the attention and is of particular importance in ornamental gardening is the large-sized flowers of the polyploid phlox (Fig. 1). And though the flowering in the

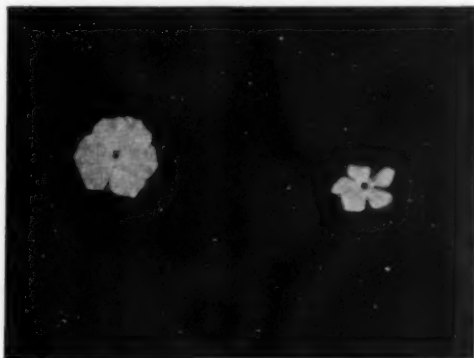


FIG. 1. Exhibiting the bigger flower character of induced polyploid phlox.

treated plants was delayed, the blooming period was considerably prolonged.

Dept. of Agric. Botany, S. S. SAXENA.  
Govt. Agric. College, J. S. NANDA.  
Kanpur, March 5, 1960.

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# NATURAL HYBRID BETWEEN ARGEMONE MEXICANA AND A. OCHROLEUCA

ALL the earlier records<sup>1-3</sup> reveal that the genus is represented in this region, for that matter in the entire Indian sub-continent, by only one species, *A. mexicana* Linn. This species is a winter weed of waste places and possesses bright-yellow flowers. Besides this, the writer discovered two years back small populations of white-flowered plants of *Argemone* in and around Patiala. These differ from *A. mexicana* not only in flower-colour, but also in vegetative characters. The two types grow intermixed in several sites and in such places there is a limited amount of hybridization (1%) between them. The hybrid individuals are gigas but intermediate in all the qualitative characters and are totally sterile. The two forms together with their spontaneous hybrids are being subjected to a critical cytotaxonomical analysis.

Taxonomically only the yellow forms constitute the true *A. mexicana* Linn. A thorough sampling of this species reveals persistently  $n = 14$  (Fig. 1). A perusal of the pertinent literature<sup>4</sup> reveals that the white-flowered form is *A. ochroleuca* Sweet subsp. *ochroleuca* which has also been discovered by Venkatesh recently. This species has  $n = 28$  (Fig. 2) which is in agreement with a recent report of  $2n = 56$  by

Venkatesh.<sup>5</sup> Both the species have normal meiosis and perfect fertility. The hybrid individuals possess  $2n = 42$  and at meiosis all the 42 chromosomes may remain as univalents (Fig. 3), or there may be varying number of univalents and bivalents and rarely trivalents may also occur. Further course of meiosis is irregular, resulting in 90% pollen and total seed sterilities.

Darlington and Wylie<sup>6</sup> conclude that the basic number of the genus is 7, even though no species with this number has been discovered so far.<sup>4,5</sup> If it is correct, then *A. mexicana* is tetraploid, *A. ochroleuca* is octoploid and the hybrid individuals are hexaploid in constitution. However, in view of the strong qualitative differences between the two species, the persistent bivalent formation in *A. ochroleuca* and the lack of extensive trivalent formation in the hybrids, the writer is of the opinion that *A. ochroleuca* cannot be regarded as a simple autopolyploid of *A. mexicana*.

It is of interest to mention that *A. mexicana* is a Central American species which has naturalized admirably in India. Keeping in view the fact that to date only this species has been reported to occur in India,<sup>1-3</sup> the white-flowered form has been so far popularly thought to be a simple mutant of *A. mexicana*. However, the present investigation amply reveals that such is not the case, since the white-flowered form is a morphologically well recognised and cytogenetically distinct species, *A. ochroleuca*. It seems to have been introduced recently, as is clear from its localised distribution. However, it is gradually establishing itself.

Biology Department, S. K. MALHOTRA.  
Mahendra College,  
Patiala, March 9, 1960.



FIGS. 1-3. Fig. 1. *Argemone mexicana* ( $n = 14$ ). Fig. 2. *A. ochroleuca* ( $n = 28$ ). Fig. 3. Spontaneous hybrid ( $n = 42$ ). (All,  $\times 1,760$ ).

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## STUDIES IN THE PROPAGATION OF PEACH BY STEM CUTTINGS WITH THE AID OF GROWTH REGULATORS

The commercial method of propagation of peach is by budding on its own seedling. The germination of peach stone is very uncertain, and the number of seedlings available is always poor. The budded plants have got to be nurtured in

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TABLE I  
Showing response of growth regulators on rooting in stem cuttings of peach variety  
Sharbati

Growth regulators	Concentration in p.p.m.	Soft wood cutting			Hard wood cuttings		
		Rooting percentage	Average No. of roots per cutting	Average length of root in cm.	Rooting percentage	Average No. of roots per cutting	Average length of root in cm.
Beta-indole butyric acid	20	30	9.3	6.5	10	3.0	3.2
	40	60	15.2	9.5	15	4.6	4.5
	60	75	16.2	11.5	20	9.5	4.4
	80	55	8.4	6.8	15	5.3	3.2
	100	45	7.1	4.5	10	6.0	1.2
Alpha-Naphthalene acetic acid	20	15	4.6	5.3	5	4.0	1.2
	40	35	6.1	7.5	15	6.6	3.5
	60	25	1.2	8.5	15	6.3	2.9
	80	20	6.2	4.4	10	6.0	2.5
	100	15	7.0	4.3	10	4.5	2.3
Control	.. ..	Nil	..	..	..	..	..

the nursery for one year, and the cost of production is thus increased. Propagation of peach by softwood cuttings<sup>1</sup> and stem cuttings under mist<sup>2</sup> has been reported from other countries, but the technique appears difficult for commercial use. The present study was, therefore, undertaken to find out an easier and more economic method of propagation of peach variety Sharbati, under ordinary conditions of temperature and humidity.

Cuttings of uniform thickness were obtained at random, from current season's growth (softwood cuttings) and from one year old mature shoots (hard wood cuttings) from six years old trees. The basal ends were dipped for twenty-four hours in 20, 40, 60, 80 and 100 parts per million solutions of beta-indole butyric acid and alpha-naphthalene acetic acid. Untreated cuttings were dipped in distilled water for similar duration to act as checks. The cuttings were then washed with tap-water and planted in sand-filled pots in the first week of September at the rate of 20 cuttings per treatment. The pots were kept in partial shade of the trees. The pH of the rooting media was found to be 7.7.

Cuttings examined six weeks after planting yielded encouraging results (Table I).

It is seen from Table I that all the treatments have encouraged rooting. No rooting is observed in the untreated cuttings. Softwood cuttings are generally superior to hardwood cuttings in respect of rooting. IBA appears more effective in inducing roots than NAA in

the concentrations used. Treatments with 40 to 60 parts per million IBA appear to be the best.

A comparable estimate of the extent of rooting response by IBA can be well observed from Fig. 1.

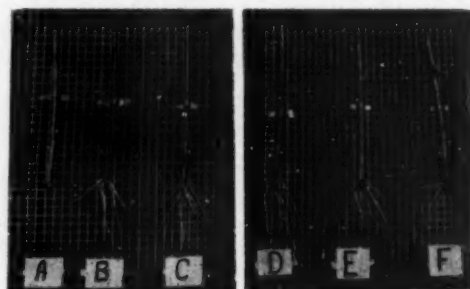


FIG. 1. Six weeks old softwood stem cuttings of peach var. Sharbati, treated with A-control; B-20; C-40; D-60; E-80; and F-100 p.p.m. of IBA.

Further work to establish the suitability of growth regulators for practical adaptability is in progress.

Govt. Agric. College,  
Kanpur (India),  
March 18, 1960.

O. S. JAUHARI.  
V. P. KOHLI.

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# CHROMOSOME COMPLEMENT AND MEIOSIS IN *PHEROPSOPHUS BIMACULATUS* (COLEOPTERA, CARABIDAE)

Our earlier knowledge about the cytology of the family Carabidae is largely due to Stevens<sup>1</sup> and Yosida.<sup>2</sup> Recently Smith<sup>3-4</sup> has recorded the chromosome numbers of seventeen species. Asana *et al.*<sup>5</sup> reported the chromosomes of only one Indian species *Anthia sexguttata*. The present report gives a description of the structure and behaviour of chromosomes during mitosis and meiosis in *Pheropsophus bimaculatus*. The adult males were collected from Alfred Park, Allahabad. Testes were dissected out from living specimens in normal saline and fixed either in SanFelice or in Corrosive sublimate acetic. Both of them gave good results. Sections (10-12  $\mu$ ) stained with Newton's gentian violet and Feulgen's stain were examined.

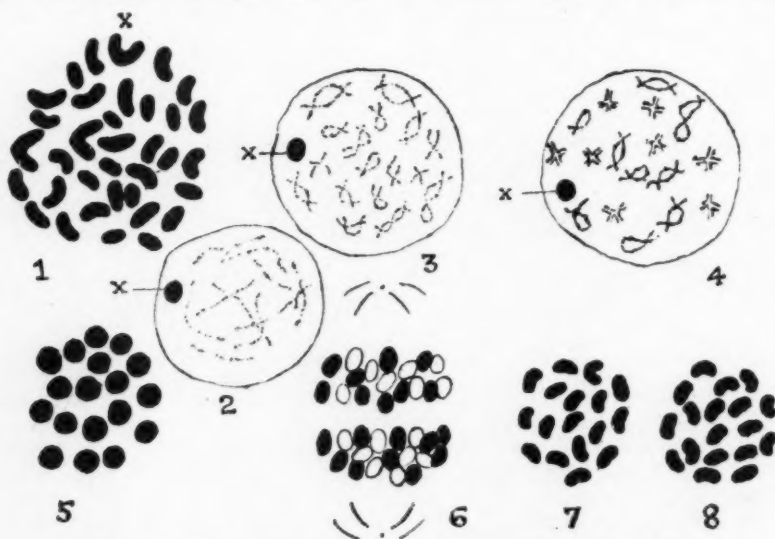
## SPERMATOGONIA

Thirty-five chromosomes are present in the

somes in the complement. In the metacentric group, two chromosomes form a homologous pair of autosomes while the remaining unpaired one is probably the X-chromosome. The latter exhibits no special characteristic enabling one to distinguish it from the autosomes.

## MEIOSIS

During the early prophase stages of meiosis the X-chromosome can easily be distinguished from the autosomes. It appears as a deeply-stained, oval body lying near the nuclear membrane (Fig. 2). At diplotene (Fig. 3) the nucleus exhibits 18 elements of which 17 are autosomal bivalents and the remaining one is the X-chromosome. The autosomal bivalents are very fine threads and contain 1-2 chiasmata each depending on the length of the bivalent. The smaller bivalents usually have only one chiasma each. The diplotene is succeeded by diakinesis (Fig. 4). The early diakinetic autosomal bivalents show considerable condensation



Figures have been drawn with the help of Camera lucida at a magnification of ca.  $\times 5,000$ .

FIGS. 1-8. Fig. 1. Spermatogonial metaphase, Fig. 2. Early prophase showing the heteropycnotic sex chromosome. Fig. 3. Diplotene showing 17 autosomes and an X-chromosome. Fig. 4. Diakinesis. Fig. 5. Metaphase I, showing 18 chromosomes including an indistinguishable X-chromosome (Polar view). Fig. 6. Anaphase I. Fig. 7. Metaphase II (Polar view) showing 17 autosomes only. Fig. 8. Metaphase II (Polar view) showing 18 chromosomes, 17 autosomes and an indistinguishable X-chromosome.

spermatogonial metaphase (Fig. 1). They are more or less similar in size. It is, however, possible to identify three V-shaped metacentric chromosomes which stand out from the rest of the rod or kidney-shaped acrocentric chromo-

and have usually the same number of chiasmata as at the diplotene.

The first metaphase plate clearly exhibits 18 chromosomes of which 17 are autosomal bivalents and the remaining one is the univalent X-

chromosomes (Fig. 5) stained, in a rich interior. partners normally without spindle of the secondary and the (Figs. 8) some at or less than. All the rod-shaped ensuing autosomes. The w vision of is grateful encourag cal Survey tion of the Divn. of Central Lucknow

1. Stevens
2. Yosida
3. Smith
4. —, H
5. Asana *et al.*

## A FLOW STOCK

An inter- fruiting of this year. year old, month of the season union, the parent mo stage of u stem and blossoms It appea tion was tion of flo a the roc setting of stock both

chromosome. As seen in the polar view (Fig. 5) all the chromosomes appear deeply-stained, spherical bodies arranged more or less in a ring with a few elements lying in the interior. At the first anaphase (Fig. 6) the partners of the autosomal bivalents separate normally and the X-chromosome goes intact without dividing to one of the poles of the spindle along with the autosomes. As a result of the first meiotic division two types of secondary spermatocytes are produced—one with and the other without the X-chromosome (Figs. 8 and 7). The distribution of the chromosomes at the second metaphase resembles more or less that of the first metaphase chromosomes. All the chromosomes in the polar view appear rod-shaped and almost equal in size. In the ensuing division the X-chromosome and the autosomes divide equationally.

The work has been done under the supervision of Dr. M. D. L. Srivastava and the author is grateful to him for his keen interest and encouragement and to Dr. A. P. Kapur, Zoological Survey of India, Calcutta, for the identification of the material.

Divn. of Microbiology, **UMA AGARWAL.**  
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Lucknow, February 12, 1960.

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#### A NOTE ON PRODUCTION OF FLOWERS AND FRUITS ON ROOT- STOCK STEM OF MANGO GRAFT IN THE NURSERY

An interesting phenomenon of flowering and fruiting of rootstock stem in mango was observed this year. Inarching was practised on a two-year old, vigorous seedling rootstock late in the month of September. Due to late operation in the season and the possibility of doubtful graft union, the graft was not separated from the parent mother plant of Bombay variety. In that stage of union, before separation, the rootstock stem and the scion shoots showed conspicuous blossoms and fruits.

It appears that after the union of stock and scion was established, the metabolic translocation of flower-forming substance was affected in the rootstock as well. The result being the setting of flowers and fruits in the scion and stock both (Fig. 1).



FIG. 1. A mango graft showing fruits on the root stock in the nursery. A—Graft union; B—Rootstock stem bearing fruits; C—Bearing scion shoot.

Govt. Fruit Preservation **B. N. AGNIHOTRI,**  
and Canning Institute,  
Lucknow, U.P., April 28, 1960.

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#### MALE-STERILE OFF-TYPE PLANTS IN THE PASTURE GRASS, *SEHIMA* *NERVOSUM* STAPP.

We<sup>1</sup> reported the occurrence of a male-sterile plant and a pistillate plant in the pasture grass, *Panicum antidotale* Retz. (Blue-panic). The male-sterility was of the functional type. During 1958, we discovered two male-sterile plants in *Sehima nervosum* in the culture accessioned as I.W. 1504, the material of which was collected the previous year near Nagpur (Bombay State). In both these male-sterile plants, meiosis during microsporogenesis was observed to be normal ( $n = 20$ ), but the development of the pollen grains was much retarded and the pollen-sacs were found to contain a mass of undifferentiated inviable pollen grains. The plants did not set any seed whereas in the normal sister plants in the culture seed-setting was abundant.

The ear in *Sehima nervosum* is a solitary raceme comprising two rows of each of pedicelled and sessile spikelets. Each of these two types of spikelets contains two florets—a bigger upper floret and a smaller lower floret. The florets of the pedicelled spikelets are all staminate whereas in the sessile spikelets the upper floret is hermaphrodite and the lower staminate. In the normal plants, at anthesis, the anthers from bigger florets extrude first and those from the smaller florets afterwards. In one of these male-sterile plants, the anthers were found not to extrude



at all, whereas in the other only anthers of the bigger florets extruded and not those from the smaller florets. This distinction between the two male-sterile plants was retained in the clonal progenies derived from the respective original plants. The former type of behaviour of anthers in male-sterile plants was reported by Narayan<sup>2</sup> in the case of *Pennisetum clandestinum* Hochst.

Both these plants were used as female parents in crosses involving marker genes for (a) ascertaining the genetic basis of male-sterility and (b) determining the mating system in this species. The results obtained so far suggest that the inheritance of male-sterility may be of the extra-nuclear type, and that the mating system is fully sexual. The male-sterile clones are being utilised more extensively for further studies for confirming the above results as also in interspecific hybridisation.

Division of Botany,  
Indian Agric. Res. Institute,  
New Delhi, April 11, 1960.

A. B. JOSHI.  
B. D. PATIL.

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### OCCURRENCE OF *TANYMECUS* WEEVIL IN PEST FORM IN THE PUNJAB AND ITS CONTROL

*Tanymecus indicus* Fst. (Coleoptera: Curculionidae) has been known as a localised pest of rabi crops in the Brara area of Ambala District in the Punjab since 1955. It suddenly appeared as pest of rabi crops in October and November, 1959, in severe epidemic form over extensive areas in Rohtak and Gurgaon Districts and in localised patches in Brara and Rayya areas of Ambala and Amritsar Districts respectively. Tens of thousands of acres of wheat, barley, gram, peas, lentil (*Lens culinaris* Medic.), taramira (*Eruca sativa* Lam.) and mustard are reported to have been devastated and had to be resown. Records of this weevil having appeared as a sporadic pest during various years in Assam, West Bengal, Madhya Pradesh, Uttar Pradesh, Bombay, Madras and East and West Pakistan and damaging large areas under wheat, barley, gram, peas and poppy are available in literature (Chaturvedi, 1952; Banerjee and Basu, 1954 and Srivastava and Nigam, 1958). In addition, crops like rice, maize, jowar (*Sorghum vulgare* Pers.), cotton, jute, sannhemp, safflower, indigo and beetroot are known to have been

damaged. It was reported to have also appeared in Rajasthan in 1959. The weevil does not seem to have been recorded from any other country outside of the Indian subcontinent.

*Tanymecus indicus* (Marshall, 1916) is a black to greyish-brown weevil, about 4½ mm. to 7½ mm. long and 1¼ mm. to 2¼ mm. broad. It lives in loose dry soil under clods, comes above the ground occasionally. It cuts the main stem of seedlings of cereals, etc., at or a little below the soil surface. The young plants are attacked only in the very early stages of their growth. In severe cases of attack resowing of the crop has to be resorted to. Not much is known about the life and seasonal histories of the pest.

#### CONTROL

Raking of BHC 5% dust at 20 lb. per acre (Chaturvedi, 1952) or aldrin 5% dust at the rate of 15-20 lb. per acre (Srivastava and Nigam, 1958) and irrigation of the soil (Anonymous, 1959) have been recommended as effective control measures. Insecticidal trials carried out in the Punjab during 1959 generally confirmed these results, and it was found that BHC 10% dust at 20 lb. per acre and aldrin 1% dust up to 200 lb. per acre were very effective in killing 95-96% and 93-85% respectively of the weevils when raked into the top 8 cm. of the soil and also helped in saving most of the germinating crop from the ravages of the weevils. BHC will be the preferred insecticide as the cost of insecticide per acre in its case is Rs. 4-00 as compared to Rs. 54-00 in the case of aldrin.

The recommended control measures of raking BHC 10% dust at 20 lb. per acre was applied over 3,052 acres of germinating rabi crops as a pretreatment during November 1959 in the Rohtak, Gurgaon, Ambala and Amritsar Districts with satisfactory results by the Punjab State Plant Protection Organisation.

Entomological Laboratory, SARDAR SINGH.  
Govt. Agric. College, M. S. GURAM.  
Ludhiana, March 18, 1960.

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## REVIEWS

**Confluent Hypergeometric Functions.** By L. J. Slater. (Cambridge University Press), 1960. Pp. xi + 247. Price 65 sh. net.

Physicists and applied mathematicians very often meet with differential equations whose solutions depend on functions known as the confluent Hypergeometric Functions'. There is a chapter devoted to these functions in Whittaker and Watson's *Modern Analysis*, but it is hardly possible to find a book which devotes more than one chapter to these functions. The author who has published a number of papers on the subject has endeavoured to collect every interesting result associated with these functions and bring them in a single volume, in the same way as Watson did for Bessel functions.

The book is divided into two parts. Part I deals with the four confluent hypergeometric functions  ${}_1F_1(a; b; x)$ , its associated solution  $U(a; b; x)$  and the two Whittaker functions  $W_{k, m}(a)$  and  $W_{k, m}(a)$ . Part II contains tables of the function  ${}_1F_1(a; b; x)$  over those ranges most useful in practice.

The properties of the confluent hypergeometric functions are covered in six chapters. Chapter I the author introduces the differential equations of which the confluent functions are the solutions. Chapter II deals with the differential properties of these functions, such as the recurrence relations and addition theorems satisfied by them. Chapter III discusses the integral representation of the functions, and the Mellin, Hankel and Laplace transforms of the Whittaker functions and the function  $U(a; b; x)$ . Chapter IV deals with the asymptotic expansions of these functions for large values of  $x$ ,  $a$ ,  $b$ ,  $k$  or  $m$  and in Chapter V, some of the well-known functions like the Bessel and Laguerre functions are derived as special cases of the confluent hypergeometric functions. Chapter VI deals with the descriptive properties of the confluent functions, and the numerical evaluation of the Kummer functions. As a result of the development in computers and numerical analysis, a vast fund of knowledge has accrued which would not otherwise have been obtained by pure reasoning alone, and this chapter discusses some results obtained by numerical solution of the zeroes of these functions.

The Appendix I to the book gives the numerical values of the zeroes of the function

${}_1F_1(a; b; x)$  for different values of  $a$  and  $b$ . Appendix II gives a Table of  ${}_1F_1(a; b; x)$  over the range  $a = -1.0(0.1)1.0$ ;  $b = 0.1(0.1)1.0$  and  $x = 0.1(0.1)10.0$ . Appendix III contains a Table of  ${}_1F_1(a; b; 1)$  over the range  $a = -11.0(0.2)2.0$  and  $b = -4.0(0.2)1.0$ .

As the first comprehensive and detailed book on the confluent functions, the present volume is bound to stimulate the interest of mathematicians and physicists in these functions, and thus pave the way for future developments. The author and the Cambridge University Press should be congratulated—the former for writing the book and the latter for the excellent printing.

V.

**Nuclear Electronics.** (International Atomic Energy Agency, Karntner Ring, Wien I, Austria), 1959. Pp. 452.

This publication contains within its cover fifty original contributions by scientists who attended the International Colloquium on Nuclear Electronics organised by Societe Francaise des Radio-electriciens in Paris, in September 1958. Apparently five sessions were held, each session devoted to a particular aspect of nuclear electronics. The papers are accordingly grouped under five headings: Scintillation Radiation Detectors and Gamma-ray Spectrometers, Pulse Technique Fast Electronics, Pulse Technique Classical Electronics, Reactor Control Measurements. Quite a number of papers are in French but this is not a great disadvantage.

The publication will be of interest to all those who are interested in nuclear electronics.

A. J.

**Indian Scientific and Technical Publications Exhibition, 1960. A Bibliography.** (The Council of Scientific and Industrial Research, New Delhi-1), 1960. Part I. Pp. 199, Part II. Pp. 195. Price Rs. 25-00.

In February, 1960, the Council of Scientific and Industrial Research organized an exhibition of scientific and technical books published in India. In spite of the best efforts on the part of the organizers, the response seems to have been "not wholly satisfactory".

This is evident from the publication under review which is the Bibliography of the books displayed at the Exhibition and compiled by the National Library Calcutta. It contains, according

to the Statistical Table given at the end of the volume, 4801 entries out of which 1893 are publications in English and the rest in the 13 Indian languages with Hindi (814) heading the list and Marathi (358) closely beating Bengali (348) for the second place, Assamese (15) comes last.

The Bibliography is divided into two almost equal parts, Part I containing the publications in Indian languages (Pp. 1-113) followed by an alphabetical index (115-98); and Part II the publications in English (1-112) with an alphabetical index (113-95). The titles of the books in the Indian Languages are given in English script and for classification the Dewey Decimal System has been followed. The classification is limited to 500 Pure Science and 600 Applied Science and Technology. The following are two samples taken at random from Part I.

523 Dirghavṛttalakṣaṇam, a treatise on the properties of the eclipse (Sanskrit).

599.61 Gaṇaśāstra sār, pakṣī lakṣaṇ āṇi cikitsā va cittā vahāgās cikitsā (Marathi).

The Bibliography will be of value only to libraries. Much labour and money have gone into the production of what is of extremely limited utility.

A. S. G.

**Structure Reports.** Vol. 16 for 1952. General Editor: A. J. C. Wilson. (The International Union of Crystallography), 1959. Pp. 651.

This volume of structure reports is divided into three sections: Metals, Inorganic Compounds, and Organic Compounds. While the arrangement in the metals section follows the alphabetical order, in the organic and inorganic sections, it is according to increasing order of complexity of composition; related substances and structures being kept together. Apart from X-ray, electron and neutron diffraction, structural information is obtainable from nuclear magnetic resonance studies, Raman, infra-red and microwave spectroscopy. Experience in recent years has amply justified in regarding, especially the former, as a highly useful tool for deriving such information. The contributors' job will become in the coming years somewhat more complex in view of the fact that information likely to interest the readers of *Structure Reports* may lie hidden quite often under a different title. However, past record of structure reports certainly promises that nothing significant will be missed.

It will be superfluous to point out the usefulness of this volume to X-ray crystallographers, solid state physicists and structural chemists.

**Electrical Circuit Analysis.** By K. Stephens (Cleaver Hume Press Ltd., London), 1959. Pp. 259. Price 30 sh.

This is a book on elementary d.c. and a.c. circuit theory written for the benefit of students at the level of the first degree as well as those taking a diploma in electrical engineering. Tracing the history of the confusion and error in the students' minds to their inability to make correct use of the basic Kirchhoff's voltage and current laws, the author proceeds to remedy the situation by devoting an appreciable part of the book to a thorough treatment of the fundamentals of d.c. circuit theory. With numerous illustrative examples he points out the way of logically approaching circuit problems and dealing with them. There are two chapters on magnetic and dielectric circuits. The rest of the book is devoted to a.c. circuit theory—explanation of the concepts of wave-form, power, impedance, power factor, etc. enunciation of the basic laws and theorems; and an introduction to polyphase circuits and the technique based on symmetrical components. Non-linear wave-forms encountered in electrical engineering are discussed briefly and the Fourier series is explained.

The text is very lucidly written and is bound to fulfil the author's hope of infusing confidence in the beginner.

S. SAMPAT

**Oxidation-Reduction Potentials of Organic Systems.** By W. M. Clark. (The Williams and Wilkins Company, Baltimore, U.S.A.) 1960. Pp. x + 584. Price \$13.50 net.

The data on oxidation-reduction potentials of organic systems have been used in a variety of fields like biology, biochemistry, etc. For energy calculations for some processes of biochemical interest depend on the data for specific oxidation-reduction systems. Professor Clark has in this book discussed the techniques employed in collecting such data, the theoretical implications of the data and their uses. In view of the importance of these data for structural work in biology and chemistry, a book of this kind was much needed.

There are fourteen chapters in the book on the existing data on the organic oxidation-reduction systems have been summarized

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of fields like biology, biochemistry, etc. For energy calculations for some processes of biochemical interest depend on the data for specific oxidation-reduction systems. Professor Clark has in this book discussed the techniques employed in collecting such data, the theoretical implications of the data and their uses. In view of the importance of these data for structural work in biology and chemistry, a book of this kind was much needed.  
There are fourteen chapters in the book on the existing data on the organic oxidation-reduction systems have been summarized

hundred tables. The author does well by going to the details of the basic principles involved rather than merely giving a report on the combination of the results. In fact, the major portion of the discussion is on the themodynamic principles. The author not merely discusses as how to treat the data, but also clearly points out their applications and limitations. The diagrams in the book point out certain general principles in addition to presenting specific details.

The material has been presented by the author in such a way as to render the book useful as a text or a reference book or a guide to a research worker in the field. The book is bound to be valuable to chemists and biologists.

C. N. R. RAO.

**Production in Domestic Animals, Vol. 1.** Edited by H. H. Cole and P. T. Cupps (Academic Press Inc., New York and London), 1959. Pp. xv + 651. Price \$14.50.

Economic animal production is of paramount importance for human welfare and "the rate efficiency of the process of reproduction is the basis of economic production in animals". In view of this, innumerable studies have been made on the reproductive processes of various domestic animals during the last three decades. Advances in the science of endocrinology provided further stimulus for studies in the reproductive processes of animals. Moreover, as a result of the extensive use of artificial insemination in animal breeding, rapid strides have been made in researches on spermatogenesis, biology and biochemistry of semen and on factors affecting sex libido. As a result of the investigations which have taken place in recent times, good deal of informations have been collected on animal reproduction which are scattered in various scientific and reviewing journals. A treatise which contains the sieved information in the field after the chaff has been removed would therefore be welcome to any worker in the field of animal production.

The present treatise which is the first of the two volumes to be published by the Academic Press on the subject has been edited by two recognised authorities on the subject. The senior author who is the Head of the Department of Animal Husbandry, College of Agriculture, University of California, Davis, California, is internationally famed and has distinguished himself for many an important contribution in animal reproduction.

The present volume is divided into sixteen chapters written by eminent authors on the subjects. Altogether eighteen authors have collaborated in the production of this volume. The first two chapters deal with anatomy of the male and female reproductive organs. Role of hormones in various reproductive processes has been dealt with in chapters 3 to 5. In the sixth chapter, the role of nervous system in reproductive phenomenon has been discussed. The studies on pattern of oestrous cycle in different species, e.g., cow, mare, ewe, doe; sow and dog, have been reviewed in chapters 7 to 11. The remaining chapters are concerned with the physiology of pregnancy, parturition and lactation. Studies pertaining to fertilization, cleavage, implantation of the embryo, development of foetus and foetal membranes are dealt with in chapters 12 and 13. In chapters 14 to 16, work on endocrine mechanism during pregnancy and factors affecting gestation length, parturition, development of mammary glands and initiation and maintenance of lactation has been presented.

Each chapter is followed by a list of references. Author index and subject index are given at the end.

The volume is well illustrated. The editors and the authors deserve to be congratulated and thanked for their efforts in bringing out this excellent treatise which will be of immense help for animal husbandry and veterinary students and research workers in the field of animal reproduction. The veterinary clinicians will also do well to make use of it as a reference book. This book should find a place on the shelf of all the libraries in Veterinary and Animal Husbandry colleges.

P. B.

**Human Biochemical Genetics.** By H. Harris. (Cambridge University Press, London, N.W. 1), 1959. Pp. viii + 310. Price 37 sh. 6 d.

The study of human biochemical genetics impinges on a number of disciplines, chief among them being medicine, genetics, biochemistry, chemical pathology and anthropology. In recent years, the subject of human genetics has assumed great significance owing to the increased mutation rates arising out of atomic explosions carried out by various nations in different parts of the world. Dr. Harris, who has published in 1953, an introductory volume on human biochemical genetics, has endeavoured in the present book under review, a correlation of the vast information available in the scientific literature and has succeeded remarkably well.



in presenting the same in a very concise and cogent manner.

After dealing with the general concept of "inborn errors of metabolism" and some aspects of Mendelian heredity, the author has proceeded to give an excellent discussion on the genetic blocks and amino-acid metabolism. Tyrosine and phenyl alanine metabolism and goitrous cretinism are among these specially discussed. In the next two chapters, a lucid account is given of the abnormal excretion of amino-acids (aminoaciduria) and its genetic significance and the variations in carbohydrate metabolism. The genetic importance of the formation of abnormal haemoglobins, on which considerable knowledge has accumulated in recent years, has been discussed by Dr. Harris in the next chapter. In chapters VII to IX, he has dealt with the genetic differences in blood group substances and plasma proteins as well as with miscellaneous metabolic disorders. He concludes with a critical review of the mode of action of hereditary units the genes of classical genetics.

There was a time, when heredity defects were attributed to the "action of mysterious noxious influences, carried by degenerate germ plasma and perhaps engendered by parental vice". Dr. Harris, however, has produced in this volume, well-authenticated material and has shown how, from the biochemical point of view, hereditary defects can be attributed to quite specific inborn errors of metabolism. The get-up of the book is excellent and the contents are singularly free of any printing mistakes. In the reviewer's opinion, this volume will not only be of great value to the research workers engaged in fields of study, closely related to human genetics, but will also give to the non-specialist, a general idea of the present-day views on many of the important biochemical aspects of this rapidly developing field of study.

P. S. SARMA.

"Discovery" Reports, Vol. XXX. Ascidiacea. By R. H. Millar. (Cambridge University Press), 1960. Pp. 1-160. Price 70 sh.

The 30th volume of *Discovery Reports* deals with the Ascidiacea, collected during 1925-37 by "Discovery", "Discovery II" and "William Scoresby", and by the staff of the Marine Biological Station at South Georgia. Most of the material is from the Sub-antarctic and Antarctic regions around South America. About 2,500 specimens belonging to 78 species were

collected. Of these, 13 are new species described for the first time. The paper is of special interest in view of its being the first account of south polar species, their ecology, distribution and speciation. The cold waters of the Antarctic and Sub-antarctic regions offer conditions which are strikingly different from temperate and tropical regions and this has had a profound effect not only on the size of specimens—the polar specimens tend to be much larger—but also on the directions in which new species have diverged. Conditions in the south polar regions appear to favour the emergence of new species of ascidians as other groups. The long isolation of Antarctica and the deep water barrier of the Antarctic convergence have effectively maintained the separation of populations leading to geographical speciation.

B. R. S.

Nomenclature of Plants. By Herold St. John. (The Ronald Press Co., 15 East 26th Street, New York 10, N.Y.), 1958. Pp. vii + 112. Price \$ 2.50.

Mr. Herold St. John has done a great service to advanced students of Systematic Botany by compiling exercises in Nomenclature in his book *Nomenclature of Plants*. With the aid of these exercises students are to be guided to correct interpretation and application of the latest International Code of Botanical Nomenclature. The working of these exercises no doubt will be a great advantage to students of Systematic Botany but the one big drawback is that it presupposes a working knowledge of several languages and the availability of the pertinent literature. Unfortunately, neither of these is easily available to students of Taxonomy in our Universities. The methods suggested by the author will no doubt exercise the student's reasoning and interpretative powers but it is felt that the correct names should have been indicated in some manner so that the student could have been helped in finding out the validity of their deductions.

Most of our Universities offer only an elementary course in Taxonomy and do not place stress on problems of Nomenclature. This limits the usefulness of the book to advanced students of Systematics. Yet the book is most welcome since it tries to focus attention on a very much neglected aspect of a discipline whose importance has not been fully realised.

K. N. NARAYAN.

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**The Development and the Embryonic Anatomy of the Human Gastro-Intestinal Tract.** By Niels Lauge-Hansen. (Central Publishing Company, Eindhoven, Holland), 1960. Pp. vii + 86.

A specialist, in radiology, brings into the domain of human embryology, fresh outlook on the development and embryonic anatomy of the human gastro-intestinal tract, in order to explain some type of gastro-intestinal anomalies frequently observed during radiological examinations.

Certain variances with hitherto universally accepted ideas are mentioned particularly with reference to size and shape of the liver during the various development phases, the peculiar growth habit of the gastro-intestinal tract and the types of movements of the various parts of the gastro-intestinal tract resulting in the finally observed disposition.

The monograph, profusely illustrated with Radiographs and coloured diagrams, vividly demonstrates the gastro-intestinal anomalies discussed in the text. These include subhepatic dystopia of the caecum, nonrotational intestine, sinus inverses and other anomalies of the colon, duodenum and stomach.

Besides exhibiting that such anomalies found in the adults may have arisen in the prenatal state, the author has presented new concepts and many stimulating ideas which will be of interest to anatomists, embryologists, surgeons and radiologists.

M. SIRSI.

#### Books Received

**Theory of Probability.** By W. Burnside. (Dover Pub. Inc., New York-14, N.Y.), 1959. Pp. xxx + 106. Price \$ 1.00.

**Ticks, Part V.—The Genera Dermacentor, Anoxetor Cosmiomma, Boophilus Morgarous.** By Don R. Arthur. (Cambridge University Press, London, N.W. 1), 1960. Pp. xvii + 250. Price 60 sh.

**G. I. Taylor Scientific Papers, Vol. II.—Meteorology, Oceanography and Turbulent Flow.** Edited by G. K. Batchelor. (Cambridge University Press, London, N.W. 1), 1960. Pp. x + 515. Price 75 sh.

**Aedes Aegypti, The Yellow Fever Mosquito: Life-history, Bionomics and Structures.** By Sir R. Christophers. (Cambridge University Press, London, N.W. 1), 1960. Pp. xii + 738. Price 75 sh.

**Proceedings of the International Congress of Mathematicians.** Edited by J. A. Todd. (Cambridge University Press, London N.W. 1), 1959. Pp. lxi + 573. Price 65 sh.

**Biochemical Society Symposia—No. 18—The Biosynthesis and Secretion of Adrenocortical Steroids.** (Cambridge University Press, London N.W. 1), 1960. Pp. vi + 111. Price 15 sh.

**Advances in Organic Chemistry: Methods and Results, Vol. 1.** Edited by R. A. Raphael, E. C. Taylor and H. Wynberg. (Interscience Pub., New York-1, N.Y.), 1960. Pp. ix + 387. Price \$ 12.00.

**The Chemistry of Heterocyclic Compounds, Vol. 14—Pyridine and its Derivatives, Part I.** Edited by Erwin Klingenberg. (Interscience Pub. Inc., New York-1, N.Y.), 1960. Pp. x + 611. Price \$ 49.00 (for 4 parts).

**Nuclear Science Series—Report Number 26—Sector-Focused Cyclotrons.** Edited by F. T. Howard. (National Academy of Sciences, 2101, Constitution Avenue, Washington 25, D.C.), 1959. Pp. xii + 291. Price \$ 2.50.

**Darwin's Place in History.** By C. D. Darlington. (Macmillan & Co., London W.C. 2), 1959. Pp. ix + 101. Price 9 sh. 6 d.

**Jute in India.** By B. C. Kundu, K. C. Basak and P. B. Sarcar. (The Indian Central Jute Committee; Indian Council of Agricultural Research, Queen Victoria Road, New Delhi), 1959. Pp. 395. Price Rs. 30.00.

**Cotton in India.** By B. L. Sethi, S. M. Sikka, R. H. Dastur, P. D. Gadkari, R. Balasubramanyam, P. Maheshwari, N. S. Rangaswamy and A. B. Joshi. (Indian Central Cotton Committee, 14, Nicol Road, Ballard Estate, Bombay-1), 1960. Pp. xiv + 474. Price Rs. 30.00.

**Chemical Analysis, Vol. 12—Systematic Analysis of Surface-active Agents.** By M. J. Rosen and H. A. Goldsmith. (Interscience Pub., New York-1, N.Y.), 1960. Pp. xvii + 422. Price \$ 13.50.

**The Tenth Symposium of the Society for General Microbiology—Microbial Genetics.** Edited by W. Hayes and R. C. Clowes. (Cambridge University Press, London N.W. 1), 1960. Pp. 300. Price 42 sh.

**Preservation of Fruits and Vegetables.** By Girdhari Lal, G. S. Siddappa and G. L. Tandon. (Indian Council of Agricultural Res., Queen Victoria Road, New Delhi), 1960. Pp. 358. Price Rs. 11.50.

## SCIENCE NOTES AND NEWS

**Additional Hosts for *Korthalsella opuntia* (Thunb) Merr.**

Messrs. J. Joseph and G. K. Deka, Botanical Survey of India, Eastern Circle, Shillong, write: *Korthalsella opuntia* (Thunb) Merr. is a tiny leafless, semi-stem-parasite growing as a dense, much branched erect tuft. It is not so catholic in its taste for hosts as others of similar morphological peculiarities and wider distribution in the tropics and sub-tropics. The parasite has been recently collected from the following additional hosts growing in the Cherrapunjee area (1,200 metre altitude) of Khasi and Jaintia Hills. *Cinnamomum zeylanicum* Breyn., *Camellia caduca* Clarke, *Cleyera grandiflora* Hk. f. and T., *Styrax hookeri* Clarke, *Phyllanthus glaucus* Wall., *Paurthia arguta* Dcne. These hosts are reported for the first time.

**Award of Research Degree**

The Andhra University has awarded the D.Sc. Degree to the following in the subject and for the thesis noted against each: Shri B. V. N. Sarma (Chemistry)—"Studies on the Rare Earths and Electron Transfer"; Shri G. G. K. Sastry (Geology)—"Mineralogy of Some Garnets from India and the Paragenesis and Chemical Petrology of their Host Rocks"; Shri J. Sivarama Sastry (Geophysics)—"Some Aspects of Shoreline Processes and Physical Oceanography".

Gujarat University has awarded the Ph.D. Degree to Shri Udipi Ramachandra Rao for his thesis on "The Study of Time Variation of Cosmic Rays with Directional Telescopes at Ahmedabad".

**The Institute of Physics and the Physical Society**

The amalgamation of the two bodies The Physical Society and The Institute of Physics under the name of "The Institute of Physics and the Physical Society", which was effected on May 17, 1960, marked the fulfilment of a long expressed desire by an overwhelming majority of the members of the Institute and the Society.

The Physical Society of London was founded in 1874 and on the initiative of the Society's Council The Institute of Physics was founded in 1919. The original scheme envisaged a kind of federation of societies interested in physics, to provide among other objects, rooms for meet-

ings, a library, and a common secretariat. At the time of its establishment no one could have foreseen the spectacular growth and influence of physics in the modern world. Broadly speaking before the war the scientific meetings and publications of the Institute were confined to applied physics while those of the Society were concerned more with pure physics. As, however, the boundary between these two aspects became less definite there has been increasing overlap in the activities of the two bodies and in their membership. It is not, therefore, surprising that during the past 20 years proposal for the amalgamation of the two bodies have been made repeatedly and from time to time detailed proposals examined, until eventually a satisfactory solution was worked out.

The first President of the amalgamated body is Sir John Cockroft. The Executive Officers of the new body are: Secretary—Dr. H. R. Lang; Editor and Deputy Secretary—Dr. A. C. Stickland; and Deputy Secretary—Mr. N. Clarke. The registered offices and headquarters are at 47 Belgrave Square, London, S.W. 1.

**G. J. Watumull Memorial Awards**

The Distribution Committee of the Watumull Foundation of Honolulu, Hawaii, announces the establishment of 10 Annual Awards in memory of Gobindram J. Watumull, Founder, to nationals of India for outstanding original research in Sciences or Humanities and invites nominations for the 1960 awards. The amount of the award is Rs. 5,000 or \$ 1,000 each.

Nominators may obtain application forms and further particulars from: Mrs. B. L. Sahney, 14 Talkatora Road, New Delhi.

**Symposium on "Termites"**

An international symposium on "Termites" is planned to be held at Delhi 4-12 October, 1960, under the joint sponsorship of the Zoological Survey of India and UNESCO.

UNESCO has invited to the symposium the international experts, Prof. Pierre P. Grasse, Paris; Prof. A. E. Emerson, Chicago; Prof. K. Gosswald, West Germany. Besides, the participation of a specialist from the USSR is envisaged.

Enquiries about the symposium should be addressed to the UNESCO South Asia Science Co-operation Office, 21, Curzon Road, New Delhi.

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### Summer School of Theoretical Physics

A Summer School of Theoretical Physics met for the first time in Mussoorie in May, 1959. The Report of the School has since been published in two volumes by the Ministry of Scientific Research and Cultural Affairs. It is priced Rs. 5 per volume (in India) and may be obtained from the Publications Unit, Ministry of Scientific Research and Cultural Affairs, 1E. 3, Curzon Road, 'A' Barracks, New Delhi.

### Radiation Belt Around Jupiter

Following the discovery by Sloanaker of unexpectedly intense 10 cm. radiation from Jupiter, investigations have been initiated in several radio observatories to study the radiations from the planet, especially at a wavelength of 31 cm. (960 Mc./sec.). These investigations have led to the suggestion that the radiation originates in a "Van Allen belt" surrounding Jupiter. If the emission has its origin in such a belt of electrons spiralling in a trapping magnetic field the angular extent of the source of the radiation is likely to be several times the diameter of the planet. In addition, some degree of polarization of the radiation would be expected.

Observations to test these predictions are being made at the Radio Observatory, California Institute of Technology, using a special type of instrument due to J. G. Bolton. This is a phase-switched interferometer comprising two 90-foot antennas which can be mounted on railroad tracks between stations with separations of 200, 400, 800 and 1,600 feet. The corresponding fringe spacings at 960 Mc./sec. are approximately 18, 9, 4.5 and 2 minutes of arc. Preliminary observations on the 31 cm. emission from Jupiter using the above instrument have been reported by Radhakrishnan and Roberts. These were taken in April 1960, when the diameter of Jupiter was  $\sim 0.3$  minute of arc.

Results show that the source is strongly linearly polarized, the radiation with the electric vector parallel to the equatorial plane of the planet being approximately 1.7 times as intense as in the orthogonal polarization. The radiation comes from a region several times the diameter of the disc and is more strongly polarized in the outer parts. The present observations are consistent with an equatorial ring of mean diameter about 2 minutes of arc, i.e., about three times the diameter of Jupiter.

Of the theories proposed to account for the Jovian decimeter radiation, only the cyclotron

and synchrotron theories predict strong linear polarization. For the cyclotron theory the observed intensity of radiation can be accounted for on the basis of electron densities similar to those in the earth's outer Van Allen belt, and a field  $\sim 300$  gauss in the emitting region. This would imply a field  $\sim 10^4$  gauss at the surface of the planet. The synchrotron theory would not need such strong fields, but would demand a vastly greater density of relativistic electrons. —(Phys. Rev. Letters, 1960, 4, 493.)

### A New 3-D Microscope

A microscope which gives a three-dimensional image of luminous model of the object has been designed at the Cambridge University Psychological Laboratory. It is intended particularly for use in biological research.

Unlike the conventional stereoscopic microscope, which gives an appearance of depth by providing a slightly different picture to each eye, this new instrument gives a truly solid image projected into a cube of space.

When a thick specimen is under observation by a normal microscope, only a thin section of it can be in sharp focus for any one setting of the focusing screw and it is only possible to examine the complete specimen by focusing successively through the specimen. This limitation is actually put to use in the operation of the solid image microscope. The solid image is built up by vibrating the focusing mechanism up and down so that the thin plane of focus scans the object in depth. The constantly changing image given by the scan is then projected into a screen which vibrates in precise synchrony with the object scan but with greater amplitude. The magnified image is formed in the cube of space swept by the vibrating screen and the high rate of scanning makes the image quite steady.

The instrument thus has the important advantage over conventional stereoscopic microscopes that thick sections can be observed in depth. Apart from biological applications, the solid image might be a useful way of displaying nuclear tracks in blocks of emulsion for cosmic ray research. One disadvantage is that the solid image suffers from lack of contrast due to the ambient light in the cube space in which the image lies, and this can be serious.

It is possible to dispense with vibrating parts in favour of just two rotating optical elements mounted on a single shaft. This may prove a simple and effective way of providing solid

images once the technical difficulties of making the special optical surfaces are overcome. —(D.S.I.R. News.)

#### Anomaly in the Heat Capacity of Chromium

Several properties of pure chromium metal show an anomalous temperature dependence in a broad temperature region below 50° C.; the temperature coefficients of some (e.g., Young's modulus expansivity) undergo an abrupt reversal of sign at about 38° C. Results of detailed investigations by Beaumont *et al.* (*Phil. Mag.*, 1960, 5, 188) of the heat capacity of chromium in the region -5 to 51° C., show a lambda type anomaly in this property, the maximum occurring at  $38.5 \pm 0.5^\circ \text{C}$ . These results also suggest that this anomaly in heat capacity is not to be ascribed to the presence of small amounts of impurities, such as oxygen or nitrogen, in the lattice. On the other hand the anomaly must be a reflection of a change in the chromium lattice itself.

Neutron diffraction methods have recently confirmed that high purity chromium becomes weakly antiferromagnetic below about 40° C. The shape and position of the heat capacity anomaly are consistent with an antiferromagnetic transition.

#### Magnetic Annealing

Magnetic annealing is the production of directional properties in a homogeneous alloy by allowing it to cool from a high temperature in the presence of a strong magnetic field. According to an announcement issued by the Bell Laboratories, recent experiments have thrown some light on the problem of magnetic annealing in the case of permalloy which is in great demand in the form of fine tapes in electronic memory devices, where their switching times under suitable conditions are very short. The new experiments indicate that the magnetic annealing is not effective unless about 14-20 parts of oxygen per  $10^6$  are present in the permalloy, and there is little beneficial change in increasing the oxygen content beyond

these limits. While the mechanism by which the oxygen acts is not clearly understood, it is suggested that atoms are deposited on a crystal stacking plane at high temperatures, and result in a displacement or dislocation of the next plane of atoms in the alloy. Whether this suggestion is correct or not, it certainly appears that close control of oxygen content is necessary.

#### Soviet Satellite Ship Completes a Month in Space

On June 15, the heaviest Soviet space ship satellite (4,540 kgm.) launched on May 15, completed 486 circuits around the Earth, covering a total of 20.9 million kilometres. The last stage of the carrier rocket completed 501 circuits during the period, travelling 21.1 million kilometres.

Since the space ship went into its new orbit its revolution period has decreased by 54 seconds and now amounts to 94.16 minutes. Its apogee and perigee, which were 690 and 306.5 kilometres respectively on May 15, dropped to 675 and 304.5 kilometres on June 15.

The jettisoned pressurized cabin, weighing 2,500 kgm. and containing the dummy astronaut continues to move along an orbit close to that of the space ship, about 16 minutes behind it.

When the last stage of the carrier rocket was put into orbit, its revolution period was 91.2 minutes, and its apogee and perigee, were 369 and 315 kilometres respectively. In the past month, its revolution period has decreased to 90.65 minutes, and its apogee and perigee to 315 and 309 kilometres respectively.

Visual and radio observations of the space ship continue successfully. The beats of its 19.95 megacycle "Signal" transmitter are picked up by radio stations and amateur radio operators all over the world. The transmitter supplies the Soviet tracking stations with continuous information about the pressure and temperature in the space ship. The processing of telemetered information shows that both temperature and pressure in the ship remain within the limits of normal.—*Soviet News*.

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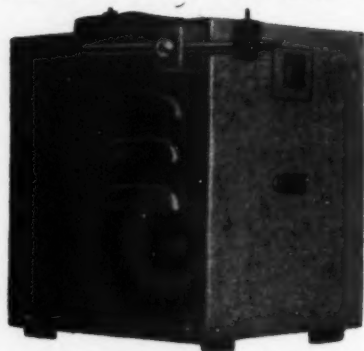
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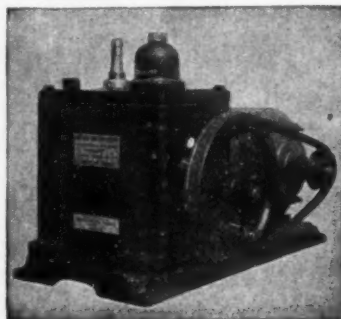
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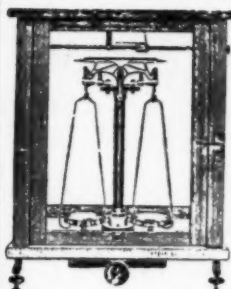


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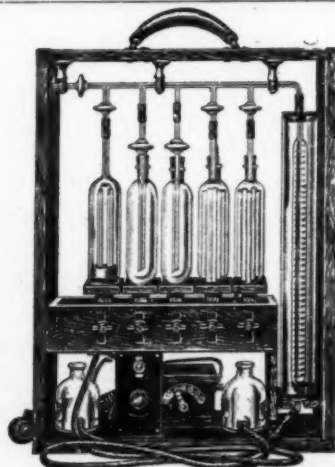
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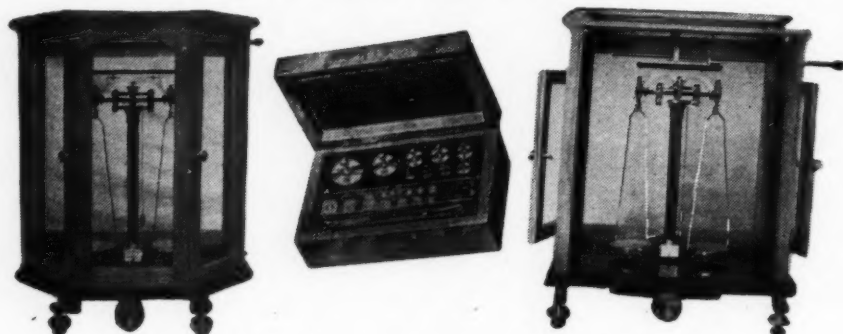
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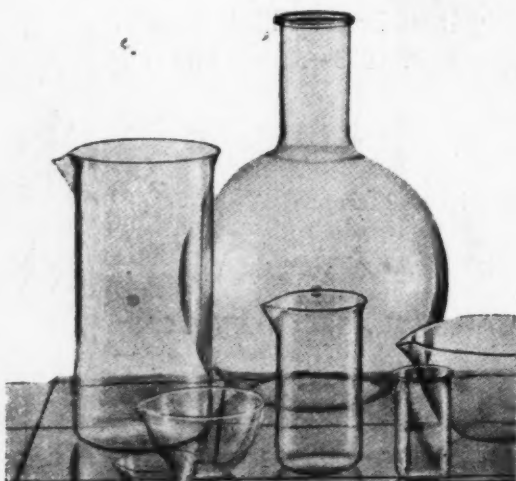
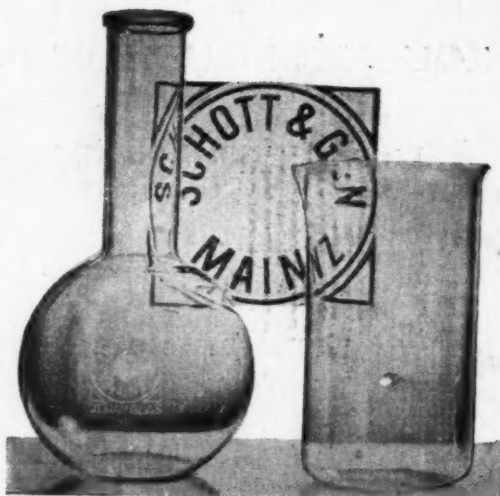
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